Illinois
Environmental
Protection Agency

Division of Water Pollution Control
2200 Churchill Road
P.O. Box 19276
Springfield, Illinois 62794-9276

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An Intensive Survey of the Lamoine River Basin 1988

AN INTENSIVE SURVEY OF THE LAMOINE RIVER BASIN

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by
MARK W. JOSEPH
Central Monitoring Unit
Springfield, Illinois

STATE OF ILLINOIS
ENVIRONMENTAL PROTECTION AGENCY
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EXECUTIVE SUMMARY

In July, 1988, the Illinois Environmental Protection Agency (IEPA) and the Illinois Department of Conservation (IDOC) participated in a cooperative survey of the LaMoine River, a sixth order tributary to the Illinois River, to evaluate the aquatic resources of the basin. Water and sediment chemistry, macroinvertebrates, fish and/or instream habitat data were sampled at nineteen stations to assess biotic potential and assign use support ratings. Site selection included one station which was part of the IEPA stream monitoring network (AWQMN). One of the driest years in history was 1988 and resulted in a 13.19 inch departure from the basins 37.6 inch average yearly precipitation. USGS records indicated that the 66 year average discharge for the LaMoine River at Ripley (DG-01) was 825 cubic feet per second compared to 7.5 cubic feet per second, measured at DG-01 in August 1988. The drought dessicated a majority of the lower order tributaries and generally reduced the mainstem LaMoine to a series of pools. Any conclusions based on these data should take into account the conditions under which the data were collected.

Data were analyzed using a variety of indices: water quality (WQI), macroinvertebrates (MBI), fish (IBI) and habitat (PIBI). Mean index values for the LaMoine River basin were 45 WQI, 5.9 MBI, 41.8 IBI and 40.0 PIBI. These values indicated minor water quality problems primarily due to phosphorus and total suspended solids. They also indicated that most of the streams sampled were capable of supporting a diverse macroinvertebrate community comprised of intolerant organisms and a highly valued fishery resource. The extent to which drought influenced these values is unclear.

When compared to the classification in Kelly and Hite (1984), LaMoine River basin mean sediment concentrations were considered highly elevated for cadmium, elevated for chromium and non-elevated for percent volatile solids, COD, total Kjeldahl nitrogen, phosphorus, arsenic, copper, iron, lead, manganese, mercury and zinc. Mean chlordane, dieldrin, heptachlor epoxide, DDT and PCBs concentrations were also classified as non-elevated.

When compared to sieved sediment data from ten Illinois river basins, the LaMoine had the highest mean manganese concentration and the lowest concentrations of COD, TKN, phosphorus, iron, mercury and zinc. However, only the DesPlaines had a higher mean cadmium level. Three basins had lower mean chromium, six basins had lower copper and three basins had lower mean lead concentrations.

Water quality problems were influenced by point and nonpoint sources. WQI values were influenced primarily by total suspended solids and phosphorus. Basinwide, point source contributions for total phosphorus were significant as municipal wastewater treatment facility effluent discharge often account for much of a stream's flow. The severity of the drought dessicated many of the lower order tributaries and greatly reduced the number of stations sampled. Nonpoint sources, which were major contributors of total suspended solids, included agricultural runoff, stream bank erosion, channelization and mining activities. Natural background was probably the cause of many low level violations of state general use water quality standards, especially regarding manganese and iron.

A total of 450.8 stream miles (USEPA stream reach lengths) were assessed in the LaMoine River basin. Of these, 340.75 miles were rated as attaining full use support. This included the lower three-fourths of the LaMoine River as well as reaches on nineteen tributaries. Reaches rated as partially supporting aquatic life uses with minor impairments were, sections of the upper fourth of the LaMoine River, the South Branch LaMoine River, Troublesome Creek and the East Fork LaMoine River. Drowning Fork and Grindstone, Killjordan and Prairie Creeks were also rated partial/minor. No reaches were rated partially supporting aquatic life uses with moderate impairments nor were any reaches rated as nonsupport.

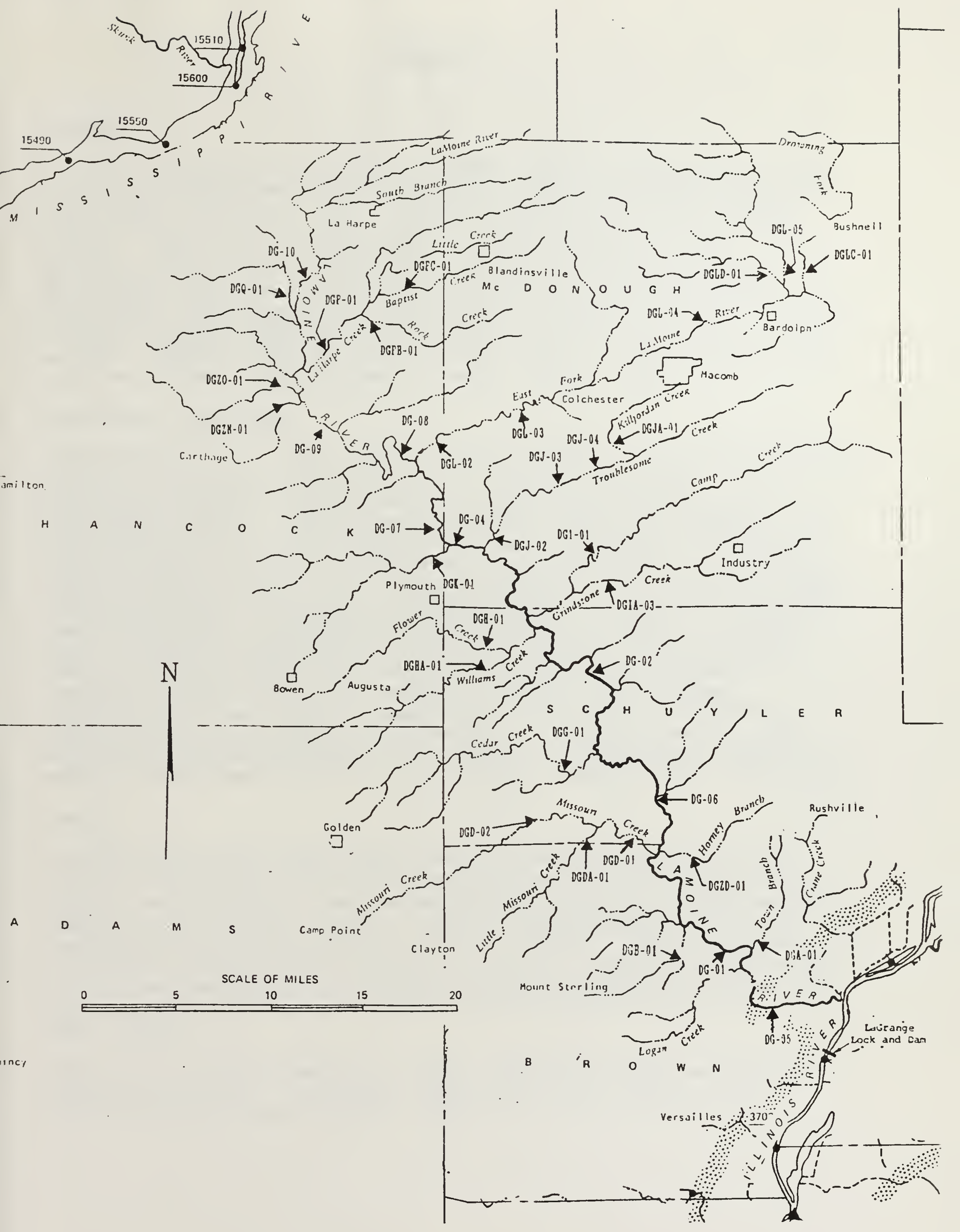

Figure 1. Location of monitoring stations in the LaMoine River basin, 1988.

INTRODUCTION

Watershed

The LaMoine River basin is located in western Illinois. The river drains a total area of 1350 square miles that includes nearly all of McDonough County, approximately the western half of Schuyler County, northern Brown County, eastern Hancock County, and small portions of Henderson, Warren, and Adams Counties. The river flows southeasterly along a meandering course approximately 100 miles in length, starting from the extreme southeast corner of Henderson County and joining the Illinois River about 5 miles below Beardstown. The average slope of the LaMoine is slightly more than 3 feet per mile, but some reaches along the channel have slopes as low as 1 to 1.5 feet per mile. Channel widths are about 100 feet along the middle course of the river and as much as 250 feet near the mouth. (Singh, 1988).

Physiogrpahy and Geology

The LaMoine River basin lies within the Galesburg plain. Much of the area was glaciated during the Pleistocene epoch by the Nabraskan, Kansan, Illinoian and Wisconsinan glaciers. (Heister and Neely, 1987). The Galesburg Plain physiographic region is charactrized by flat and broad uplands between which the larger valleys are steep-walled, alluviated, and terraced. The plain is formed primarily on till of Illinoian age, over which there is a thick cap of Wisconsinan loess (aeolian silt). Underlying bedrock is of Mississippian and Pennsylvanian age, and consists of limestone, shale, sandstone, and some coal. The Illinoian drift is comparatively well leached, and hence is a limited source of background contributions to streams. However, the Wisconsinan loess, which is ubiquitous over the area, contains a high fraction of leachable materials, which are capable of producing high background concentrations of most chemical constituents. The loess is also easily eroded, and thus is a source of large volumes of suspended sediment. The Wisconsinan drift and the bedrock are similarly -- although more locally -- capable of making major additions to background concentrations. (Flemal 1980).

Land Use

The LaMoine River basin lies within Area 27 in the Eastern Region of the Interior Coal Province. Area 27 covers 5,805 square miles in west central Illinois, most of which is used for agriculture. The area has 59.9 percent cropland and 15.6 percent pasture. Corn and soybeans are the main crops. The remaining 24.5 percent of the land is used as follows: Forest and woodland, 14.7 percent; urban and built-up area, 4.7 percent; Federal non-cropland, 0.5 percent; small water areas, 0.2 percent; mining, 0.1 percent; and other land uses, 4.3 percent (Illinois Conservation Needs Committee, 1970 as cited by Zuehls, 1987).

One surface mine began operation in 1982 in McDonough County and produced 283,428 tons of coal. Many areas in the LaMoine River basin have been previously surface mined. (Zuehls, 1987).

Climate

The climate for Illinois is classified as humid continental since it is located far from any modifying influences such as oceans or mountain ranges. Precipitation averages 37 inches/year over the LaMoine River basin. Most of the precipitation occurs between April and September. The driest months are normally February and December and the wettest are May, and June. Rainfall for the period April through September, 1988, was approximately 35% below normal (ISSN 0273-8635).

Discharges

There are numerous dischargers within the LaMoine River basin. These include municipal wastewater treatment plants (Table 1) as well as industries such as the Crossland Slaughterhouse. In addition, there are also discharges from schools, mobile home parks, feedlots, public water supplies and other small business operations.

Table 1. List of municipal wastewater treatment plants in the LaMoine River basin.

	Population	Stream Code	Process	Design Flow mgd	198 Mea mgd
Augusta	764	DGHA	Lagoon	0.2	0.0
Bushnell	3811	DGLC	Trickling Filter	0.7	-
Carthage	2978	DGZN	Lagoon	0.54	-
Colchester	1729	DGLZ	Lagoon	0.23	-
Good Hope	457	DGLD	-	-	-
Industry	600	DGIA	Lagoon	0.07	0.0
LaHarpe	1471	DGZR	Activated Sludge	0.25	0.1
Macomb	20628	DGJA	Activated Sludge	7.5	4.0
Mt. Sterling	2186	DGB	Lagoons	0.3	-
Rushville	3348	DGA	Activated Sludge/Lagoon	0.36	-

WATER QUALITY

Methods

Replicate water quality samples were collected at each station in June, July and September, with the July sample coinciding with sediment, fish and macroinvertebrate samples. Station locations are indicated in Figure 1 and described in Appendix A. Samples were collected utilizing the equal transit rate (ETR), equal width increment (EWI), multiple vertical method (IEPA, 1987). Upon collection, samples were placed on ice and transported to the Agency's Champaign laboratory for analysis. In-situ field measurements of pH, specific conductance, dissolved oxygen and water temperature were performed with a Hydrolab model 4041.

Water quality data were evaluated using state general use standards (Il Adm. Code 302, 1987) and the U.S. EPA's STORET-generated water quality index (WQI). In addition, data from two ambient water quality monitoring network (AWQMN) stations, DG-01 and 04, for the past 5 years was reviewed for trends.

The water quality index (WQI) specifically evaluates water temperature, pH, dissolved oxygen, total phosphorus, total suspended solids, conductivity (total dissolved solids), ammonia toxicity and metals toxicity (Table 2). Various ranges of index values indicate the degree of impact (IEPA, 1988):

0.0 - 30.0	no to minimum water quality problems
30.1 - 50.0	minor water quality problems
50.1 - 70.0	moderate water quality problems
70.1 - 100	severe water quality problems

Table 2. Water Pollutant Categories, Parameters and Criteria Values Used in a Water Quality Index.

Category	Parameter	Measured Water Quality Value Corresponding to Index Value			
		0	20*	60	100
Temperature	Temperature (^{o}C)	16	28	34	38
Oxygen	Dissolved Oxygen (mg/l)	11.0	5.0	3.0	2.0
pH	pH	7.5 9.0	6.5 10.0	5.5 10.5	4.5
Trophic/ Nutrients	Total Phosphorus (mg/l)	0.0	0.1	0.5	1.0
Turbidity	Total Suspended Solids (mg/l)	0.0	25	100	400
Dissolved Solids	Conductivity umhos/cm	0	750	750	3000
Inorganic Toxicity	Un-ionized ammonia (mg/l)	.001	.040	.400	4.00
Metals Toxicity**	Cadmium (ug/l)	3	20	60	120
	Chromium (ug/l)	5	1050	1250	1500
	Copper (ug/l)	5	20	100	200
	Lead (ug/l)	50	100	300	1000
	Mercury (ug/l)	0.1	0.5	2.5	6.0
	Zinc (ug/l)	100	1000	1800	8000

*Comparison criteria based on State General Use water quality standards or warmwater fish criteria.

**The worst measured value for one of the six metal parameters is used to compute the metals toxicity.

Results and Discussion

Water quality sampling was initiated in early June and continued into mid September. Over the four month period three replicate samples were to be collected at each of fourty-four sites. Due to severe drought, which left the area 10.58 inches below normal precipitation for April through September, only nineteen stations had adequate flow (a minimum of 100 yards continuous pool) by the second sampling round (ISSN 0273-8635). Round two was collected in late July along with habitat data and sediment, fish and macroinvertebrate samples. Continued drought left DGIA-03 on Grindstone Creek dry as of the September sampling round. In order to locate point scurce influences, ten facility related surveys were scheduled on streams located throughout the basin. Due to the drought a number of facilities were either not discharging or had receiving streams which were completely dry within 0.5 mile downstream of the discharge. Surveys were completed on Bushnell, Rushville and Macomb. Water quality results for nineteen stations are summarized in Table 3. The severity of the drought can be realized by comparing U.S. Geological Survey water data (Report IL-87-2) taken from the LaMoine River at Ripley (DG-01). Average discharge at Ripley was 825 cfs compared to 7.4 cfs recorded at DG-01 during the survey. The U.S.G.S. period of record was 66 years.

Water quality index values for the LaMoine River basin ranged from 13 at DG-08 on the LaMoine River to 94.7 at DGLC-01 on Drowning Fork. The mean WQI value for the basin was 45.0 representing minor water quality problems. Phosphorus (48.7) and to a lesser degree total suspended solids (29.5) were the components which most frequently exceeded the criteria when calculating the index (Tables 2 and 4). The LaMoine River sites had a mean WQI of 33.2, with total suspended solids and total phosphorus the criteria most frequently exceeded when calculating the index. When compared to the LaMoine River stations, the tributaries had a higher mean WQI (51.9). Similar criterion exceedance frequencies for total dissolved solids and a greater than two fold increase in the number of phosphorus exceedances were observed in the tributaries when compared to the mainstem (Table 4). The highest phosphorus concentrations were located on tributaries which received municipal wastewater treatment plant effluent discharges.

Of the fifty-six water quality samples collected violations of state general use water quality standards occurred for dissolved oxygen (14), pH (2), total boron (2), total iron (45), copper (1), manganese (18), conductivity (3) and total dissolved solids (1). Fecal coliform levels exceeded the standard (200/100 ml H_2O) in twenty-three of the samples collected, however, a minimum of five samples collected over a 30 day period are required to properly apply the standard. Each sample exceeded 0.05 mg/l total phosphorus.

Conductivity/TDS

Although there is no standard for conductivity, there is for total dissolved solids (1000 mg/l). Hem, 1970 as cited by Zuehls, 1987, stated that in Illinois the relationship between specific conductance and TDS is nearly linear. TDS can be approximated from conductivity by the equation $KA=S$: where K is conductance in umhos/cm at 25C; S is dissolved solids in mg/l and A is a constant ranging from 0.55 to 0.75. High values of A are commonly associated with water containing high concentrations of sulfur and can vary between basins. For the LaMoine basin a value of 0.66 was chosen. This is the conversion factor used for area 27, which included the LaMoine River basin.

Based on this conversion factor, the 1000 mg/l TDS standard is equivalent to 1515 us/cm. Conductivity exceeded this value at DGLC-01 on Drowning Fork. The source of the violation was likely the Bushnell municipal sewage treatment plant, which is located upstream of Station DGLC-01.

Dissolved Oxygen

Dissolved oxygen violations were common, with one-fourth (14) of the fifty-six samples containing less than 5.0 mg/l dissolved oxygen. Seven DO violations were recorded on the LaMoine River (three at DG-09, two at DG-08 and one each at DG-02 and 05), three violations were recorded on the East Fork LaMoine River (one violation each at DGL-03, 04 and 05) and one violation was recorded on Missouri Creek (DGD-01), Grindstone Creek (DGIA-03), Farmers Fork (DGLD-01) and Drowning Fork (DGLC-01). Dissolved oxygen concentrations ranged from 1.4 mg/l at DG-09 on the upper LaMoine River to 10.7 mg/l at DG-02 on the lower LaMoine. The mean DO value was 6.3 mg/l.

Three facilty related stream surveys failed to link any of the dissolved oxygen violations to municipal wastewater treatment processes. Reduced oxygen soluabilities due to high ambient water temperatures and little reaeration due to low flows probably resulted in a majority of the DO violations recorded. High sediment oxygen demand may have also contributed, as drought conditions eliminated the usual spring scouring of leaf litter and plant detritus which accumulated during the fall and winter. In addition, sampling did not represent diurnal fluctuations which can result in maximum DO concentrations during daylight hours and minimum values at night. Diurnal fluctuations may cause DO levels to drop below the standard.

pH

Basin wide pH values ranged from 6.3 at DGL-02 on the East Fork LaMoine River to 8.8 at DGLC-01 on Drowning Fork. The mean pH value for the basin was 7.4. Stations DG-09 on the LaMoine River and DGL-02 on the East Fork LaMoine River failed to meet the 6.5 minimum state general use water quality standard for pH. In each instance total acidity was 0.1.

Boron

Basin wide, boron concentrations ranged from 50 ug/l at eight sites to 1433 ug/l at DGLC-02 on Drowning Fork. The mean boron value for the LaMoine basin was 172 ug/l. Total boron exceeded the 1000 ug/l standard in two of the three samples collected at DGLC-01 on Drowning Fork. Boron is widely used in cleaners and detergents and is often present in sewage or industrial waste (Hem, 1970). A 1988 facility related stream survey of Drowning Fork found elevated boron levels at several stations immediately downstream from the facility's outfall (Joseph, 1988).

Total Iron

Exluding DGJA-01 on Killjordan Creek and DGL-02 on the East Fork LaMoine River, total iron exceeded the 1000 ug/l standard at all stations sampled. Three-fourths (45) of the 56 samples collected exceeded the standard. Iron concentrations ranged from 232 at DGJA-01 on Killjordan Creek to 3755 at DGLD-01 on Farmers Fork. The mean concentration in the LaMoine basin was 1549

ug/l total iron. Area soil content and resulting leachate undoubtedly has a high iron content. Non-point sources of iron in the LaMoine basin include coal mining activities, agriculture and stream bank erosion.

Manganese

One-third (19) of the 56 stations sampled exceeded the 1000 ug/l standard for total manganese. Manganese concentrations ranged from 37 ug/l at DGJA-01 on Killjordan Creek to 3301 ug/l at DGD-01 on Missouri Creek. The mean total manganese concentration in the LaMoine basin was 812 ug/l. According to Zuehls (1987) elevated manganese concentrations are common in the area of the LaMoine River basin. The highest concentration recorded was located on Missouri Creek (DGD-01), adjacent to a reclaimed coal stripmine and downstream from extensive coal mining activities. Non-point sources of manganese in the LaMoine basin include coal mining, agriculture and stream bank erosion.

Copper

Copper concentrations exceeded the 20 ug/l limit once at DGJ-04 on the East Fork LaMoine River. Copper concentrations ranged from <5 ug/l (86% of the samples) to 24 ug/l at DGJ-04 on Troublesome Creek. The mean concentration for total copper was 5.7 ug/l in the LaMoine basin.

Fecal coliform

Fecal coliform values exceeded the standard (200/100 mg) in twenty-three (43%) of the fifty-four samples collected. However, the standard does not apply since it is based on the geometric mean of five samples collected over not more than a 30 day period. Fecal coliform levels ranged from less than 10 at DG-05 on the LaMoine River to 8200 at DGL-05 on the East Fork LaMoine River. The basin had an approximate mean fecal count 1014/100 ml. At the AWQMN stations DG-01 and DG-04, the 5 year mean fecal coliform counts were 3284 and 1374/200 ml, respectively. The mean coliform count for the LaMoine River was 219 compared to 1481/100 ml for the tributaries.

Sources of fecal bacteria can be determined by the ratio of fecal coliform/fecal streptococi. Franson (1985) found that ratios greater than 4.1 were indicative of pollution from domestic waste whereas ratios less than 0.7 suggested pollution from non-human sources. Gilliland (1987) developed ratios for various land uses in an agricultural area of Nebraska. His study indicated that runoff from pasture and row crop land can contribute significant amounts of fecal bacteria from wildlife. Comparisons of these ratios suggested that of the three replicate samples collected, stations, DG-09, on the LaMoine River, DGLC-01 on Drowning Fork and DGL-05 on the East Fork LaMoine River each had one sample with fecal ratios attributed to human origin. Station DGLC-01 was immediately downstream from the Bushnell municipal wastewater treatment facility, however, no facilities were in the immediate vicinity of Stations DG-09 or DGL-05. Sampling of the remaining stations indicated a mixture of human and animal origin. Non-point sources of fecal bacteria included domestic animals, wildlife and non-sewered home sites. Fecal samples were collected in conjunction with the 1988 facility related stream surveys on Drowning Fork, Killjordan Creek and Town Branch. These streams are the respective receiving streams for the Bushnell, Macomb, and Rushville municipal wastewater treatment facility effluent discharges. On Drowning Fork mean fecal coliform counts were greatest at the facility

effluent (3553) with reduced counts found progressively downstream from the facility. Background levels (990/200 ml) were reached between 1.6 and 3.1 miles downstream from the facility effluent. Agricultural influences (grazing cattle) caused a sharp increase in mean coliform number (2260/100 ml) approximately 5.3 miles downstream from the Bushnell facility. Rushville showed the same progressive decrease in mean coliform counts as stream miles increased, however, mean coliform counts failed to fall below 200/100 ml throughout the 7.0 miles survey reach. No discernable trends were found at Macomb where the facility effluent had the lowest mean fecal coliform counts and counts generally increased with downstream miles (Joseph, 1988).

Phosphorus

The total phosphorus standard of 0.05 mg/l applies only to lakes and reservoirs and at the point of entry of any stream into a lake or reservoir. None of the stations in the LaMoine basin were located in such areas. Each sample collected exceeded 0.05 mg/l for total phosphorus. Phosphorus concentrations ranged from 0.08 mg/l at DGD-01 on Missouri Creek to 6.1 mg/l at DGJA-01 on Killjordan Creek. The mean LaMoine basin concentration was 0.95. Five year mean concentrations for the two AWQMN stations were 0.31 and 0.25 mg/l, at DG-01 and DG-04, respectively.

Total Suspended Solids (TSS)

Although there is no state water quality standard for total suspended solids, a criterion of 25 mg/l is used in calculating the WQI. It was an important parameter in the LaMoine basin since elevated WQI values were so heavily influenced by elevated TSS. Concentrations ranged from 8 mg//l at DG-08 on the LaMoine River to 155 mg/l at DGLC-01 on Drowning Fork. The mean concentration for the LaMoine basin was 51.8 mg/l. Five year mean concentrations for the AWQMN stations were 287.9 mg/l at DG-01 and 137.9 mg/l at DG-04.

Nonpoint Pollution

According to the WQI sedimentation in the form of total suspended solids was a major type of nonpoint pollution during the LaMoine basin survey. Sediment pollution is also considered one of the most serious water pollution problems in the state (Flemal 1980). The most likely sources of sedimentation include agricultural runoff, stream bank erosion as well as runoff from coal mining activities, however, point sources also contribute as the highest TSS concentration recorded during the survey was at DGLC-01 downstream from the Bushnell STP. Suspended-sediment loads and yields taken from Grindstone Creek and the LaMoine River at Ripley averaged 1400 tons per square mile per year (Zuehls, 1987) or 2.2 tons per acre. The implementation of best management practices could reduce the level of soil loss.

Phosphorus was also a major pollutant according to the WQI. Although the highest phosphorus concentrations were generally located downstream from municipal wastewater treatment plants, nonpoint sources in the form of fertilizers, animal waste and domestic waste have the potential for being significant contributors to stream phosphorus loading. Severe impairment due to enrichment from an adjacent feedlot was encountered at DGG-01 on Cedar Creek where gassification due to the decomposition of organic matter was

occurring throughout the reach. The sediments as well as the water were black and a sulfur odor was also noted.

Summary

Violations of state general use water quality standards in the LaMoine River occurred for total iron (45), manganese (18), dissolved oxygen (14), pH (2), total boron (2), conductivity (3), copper (1) and total dissolved solids (1). The elevated iron and manganese concentrations are common to the area (Flemal 1980 and Zuehls, 1987). The total boron, total dissolved solids and conductivity violations were attributed to the Bushnell municipal wastewater treatment facility. A majority of the dissolved oxygen violations were probably drought related. High ambient water temperatures and little reaeration due to low flows greatly reduced the dissolved oxygen soluabilities in the basin. The origin of the copper violation is unknown.

The mean WQI value for the basin was 45.0 indicating minor water quality problems overall. WQI criterion indicate that water quality in the basin was most influenced by trophic nutrients (total phosphorus) and total suspended solids. Sources of phosphorus include point (municipal wastewater treatment facility effluent discharge) as well as nonpoint (agricultural fertilizers, feedlot runoff and nonsewered domestic waste). Basinwide sources of total suspended solids were mainly nonpoint, with agricultural runoff, stream bank erosion and coal mining activities probably making the largest contributions, however, point sources can produce localized perturbations.

Table 3. Water quality data from the LaMoine River Basin, Spring 1988.

STATION PARAMETER	DG-01	DG-02	DG-05	DG-06	DG-07	DG-08	DG-09	DGD-01	DGJ-02	DGJ-03	DGJ-04	DGL-02	DGL-03	DGL-04	DGL-05	DGLC-01	DGLO-01	DGIA-03	DGJA-01
**Water Quality Index Value	25.5	31.6	29.4	33.2	26.3	13	73.7	34.2	67.8	74.1	71.2	20.4	30.7	38.9	41.5	94.7	44	37	67.1
Temp. Air Deg.C	--	32	31	29	--	22	33	36.5	24	25	24	22	20	24	26	27	25	30	23
Temp. Water Deg.C	23	23.8	25.4	24.6	22.5	21.2	27	27.9	19.7	19	20.6	21	21	21.2	26.3	24	22.6	21.8	20.5
Field Dissolved Oxygen, mg/l	5.8	4.8 *	3.8 *	5.7	8.3	5.9	4.4 *	8.8	6.5	6.8	6.9	7.6	6.7	6.9	9.9	7.6	6.3	4.2 *	8.4
Field Conductivity, umhos/cm	612	608	621	609	581	588	655	608	714	880	848	633	636	750	507	1163 *	517	640	651
Field pH, units	7.5	7.6	7.4	7.0	7.7	7.2	7.1	7.6	7.6	7.4	7	7.6	7.3	7.9	8.0	7.5	7.4	7.5	7
Alkalinity,total mg/l	229	239	252	252	207	264	281	261	140	107	91	208	197	217	206.5	196	209	236	85
Acidity,total	--	<1	<1	<1	--	<1	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluoride,total mg/l	0.29	0.29	0.27	0.32	--	0.29	0.32	0.3	0.83	0.89	0.84	0.34	0.35	0.47	0.31	0.69	0.31	0.36	0.86
Chloride,total mg/l	27	27	24	11	--	22	28	9.6	73	71	63	45	47.6	67	24	142	21	27	69
Sulfate,total mg/l	56	40	41	62	49	24	33	60	98	98	84	61	69.7	83	30	194	33	64	78
Nitrate& NO2-N,total	<0.1	0.1	<0.1	0.1	0.92	0.14	<0.1	<0.1	3.0	6.6	7.8	<0.1	<0.1	0.37	<0.1	3.5	0.31	<0.1	11
Ammonia Nitrogen, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	0.25	0.52	<0.1	0.13	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	0.25	0.26	<0.1	<0.1
**Unionized Ammonia, mg/l	0.002	0.002	0.002	0.001	0.002	0.002	0.004	0.003	0.002	0.003	0.000	0.002	0.001	0.004	0.006	0.004	0.003	0.001	0.000
Phenols,total ug/l	<5	<5	1	<5	--	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Phosphorus,dis. mg/l	0.03	0.05	0.05	0.03	0.05	0.06	0.02	0.04	1.0	2.0	3.8	0.08	0.09	0.13	0.12	0.68	0.12	0.07	4.6
Phosphorus,total mg/l	0.18	0.19	0.21	0.16	0.14	0.13	0.31	0.08	--	2.3	4.1	0.19	0.23	0.25	0.29	0.87	0.35	0.2	4.7
Cyanide,total mg/l	<0.00	<0.005	<0.005	<0.005	--	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BOD 5day mg/l	--	6	4	7	--	3	9	7	4	4	4	4	7	6	5	5	5	7	2
COD,total mg/l	22	24	22	20	18	19	44	20	--	26	26	21	23	21	26	22	27	34	22
Solids,tot.sus. mg/l	61	61	42	102	45	8	110	38	43	64	52	31	48	31	76	59	122	43	9
Solids,volatile mg/l	13	10	9	13	7	2	20	7	6	7	5	6	9	7	9	10	17	9	2
Kjeldahl-N,total mg/l	1.5	0.9	0.8	0.9	0.8	0.9	2.7	0.9	--	1.1	5.4	0.8	0.8	1.3	1.4	1.6	1.7	1.8	1.1
Oil,gravimetric mg/l	1	9	<1	3	--	<1	2	2	<1	4	1	1	1	2	2	1	2	2	1
Turbidity NTU	39	--	--	29	17	1.5	24	--	9.4	20	24	8.7	11	12	22	29	40	20	4.3
Arsenic,total ug/l	2	2	2	2	--	3	6	1	6	6	5	2	2	3	4	3	3	3	4
Mercury,total ug/l	<0.05	<0.05	<0.05	<0.05	<0.0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Calcium,total mg/l	64	63	69	65	56	64	67	68	38	33	29	54	54	55	46	55	51	57	29
Calcium,dis. mg/l	63	62	64	65	55	63	65	67	36	27	28	54	52	54	46	55	49	55	28
Magnesium,total mg/l	26	25	26	25	23	25	29	26	16	15	14	27	27	27	25	30	24	30	14
Magnesium,dis. mg/l	26	24	25	25	22	25	28	25	15	13	13	26	27	27	25	30	23	29	14
Sodium,total mg/l	19	21	18	19	20	13	15	13	67	66	60	27	30	48	11	119	12	19	60
Sodium,dis. mg/l	19	21	18	19	19	13	15	13	64	56	59	27	29	48	11	119	12	19	58
Potassium,total mg/l	2.8	3.1	2.9	2.7	2.8	3.6	4.9	3.7	9	9.0	8.6	2.8	2.8	2.9	2.2	5.5	2.2	3.4	8.5
Potassium,dis. mg/l	2.5	3	2.8	2.6	2.7	3.5	4.5	3.5	8.5	7.5	8.2	2.7	2.6	2.8	2.1	5.3	1.9	3.2	8.2
Aluminum,total ug/l	1631	918	632	910	645	222	1676	435	670	1099	639	437	692	574	1247	1334	2404	966	251
Aluminum,dis. ug/l	<50	1068	53	108	53	<50	84	91	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	238
Barium,total ug/l	143	145	151	154	124	149	233	135	73	68	52	132	124	137	157	133	178	123	35
Barium,dis. ug/l	118	128	127	137	106	140	187	127	55	36	33	118	104	123	129	116	128	107	32
Boron,total ug/l	<50	86	68	87	61	<50	<50	50	257	264	247	88	93	145	<50	378	<50	66	223
Boron,dis. ug/l	<50	92	63	115	62	<50	<50	<50	244	227	240	86	91	144	<50	376	<50	64	218
Beryllium,total ug/l	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<1	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Beryllium,dis. ug/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium,total ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Cadmium,dis. ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Chromium,total ug/l	<5	6	<5	<5	<5	<5	<5	<5	<5	<5	8	<5	<5	<5	6	5	7	<5	9
Chromium,dis. ug/l	<5	7	<5	<5	<5	<5	<5	<5	<5	<5	9	<5	<5	<5	<5	<5	<5	<5	10
Copper,total ug/l	<5	<5	<5	<5	<5	<5	6	<5	<5	<5	24 *	<5	<5	<5	5	<5	6	<5	<5
Copper,dis. ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	7
Cobalt,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cobalt,dis. ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Iron,total ug/l	2107 *	1550 *	1086 *	1627 *	1109 *	526	2446 *	650	1133 *	1957 *	1111 *	667	1214 *	804	1919 *	1606 *	3755 *	1126 *	232
Iron,dis. ug/lL	<50	70	<50	60	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Lead,total ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Lead,dis. ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Manganese,total ug/l	498	1255 *	980	1405 *	232	1938 *	1704 *	747	299	209	129	673	714	528	973	264	660	1224 *	43
Manganese,dis. ug/l	277	1089	562	1284	127	1851	1460	602	176	109	90	488	476	426	765	237	489	1042	41
Nickel,total ug/l	<5	6	<5	<5	<5	<5	9	<5	5	6	<5	<5	<5	<5	7	<5	7	<5	<5
Nickel,dis ug/l	<5	6	<5	<5	<5	<5	9	<5	7	5	12	<5	<5	<5	<5	<5	<5	6	9
Silver,total ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Silver,dis. ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Strontium,total ug/l	191	189	186	190	187	201	201	224	116	101	89	201	204	224	146	380	149	192	92
Strontium,dis. ug/l	186	186	183	187	180	197	193	225	109	83	85	200	200	223	145	377	144	186	90
Vanadium,total ug/l	6	6	5	<5	<5	<5	9	<5	7	8	7	<5	<5	7	10	10	12	<5	<5
Vanadium,dis. ug/l	<5	<5	<5	<5	<5	<5	6	<5	<5	<5	5	<5	<5	5	7	7	6	<5	<5
Zinc,total ug/l	<50	<50	<50	<50	<50	121	184	<50	158	<100	101	137	<100	<50	<50	<50	<100	<100	<50
Zinc,dis. ug/l	<100	<50	<50	<50	<50	<50	108	<50	226	<50	<50	172	<100	<100	<50	<100	<50	<50	<50
**Hardness, mg/l	268	257	279	265	234	262	286	275	163	145	129	245	245	250	219	263	224	266	130
Fecal coliform #/100ml	200	<50	<50	90	2600	150	<50	200	440	1100	1300	320	780	50	2100	300	--	50	1200
Fecal strep. #/100ml	--	450	50	220	--	400	--	340	1000	1200	7300	450	750	650	2900	50	350	100	4400

** Calculated value

* State General Use Water Quality Standard Violation

a: The allowable concentration varies in accordance with water temperature and ph values. In general, as both temperature and pH decrease, the allowable value of ammonia nitrogen increases.

suar/wq.wk1

Table 3. Water quality data from the LaMoine River Basin, Spring 1988.

STATION PARAMETER	DG-01	DG-02	DG-05	DG-06	DG-07	DG-00	DG-09	DGD-01	DGJ-02	DGJ-03	DGJ-04	DGL-02	DGL-03	DGL-04	DGL-05	DGLC-01	DGLD-01	DG1A-03	DGJA-01
**Water Quality Index Value	25.5	31.6	29.4	33.2	26.3	13	73.7	34.2	67.8	74.1	71.2	20.4	30.7	39.9	41.5	94.7	44	37	67.1
Temp. Air Deg.C	32	26	30	30	25	27	27	31	24	25	23	28	23	21	30	31	29	28	22
Temp. Water Deg.C	25	27.1	30	24	24.4	22	25	28	22.9	23.2	22.5	23	22	21.7	23.1	31.5	27.3	24	21.6
Field Dissolved Oxygen, mg/l	6.8	10.7	5.4	7.8	6.3	4.5 *	2.7 *	6.9	5.2	7.2	5.8	5.9	4.0 *	3.2 *	4.1 *	9.6	6.6	5.4	7.9
Field Conductivity, umhos/cm	569	525	588	539	639	582	630	558	470	660	651	695	720	876	513	1699 *	481	438	672
Field pH, units	8.0	8.3	7.7	7.6	7.5	7.4	7.1	7.6	7.2	7.4	7.2	7.7	7.5	7.5	7.2	8.8	7.6	8.0	7.4
Alkalinity,total mg/l	249	187	255	223	250	262	203	305	95	82	70	216	220	225	190.3	160	199	155	66
Acidity,total	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluoride,total mg/l	0.29	0.39	0.34	0.31	0.33	0.20	0.30	0.35	0.72	0.86	0.92	0.37	0.43	0.31	0.39	1.66	0.31	0.34	0.95
Chloride,total mg/l	20	31	20	24	34	10	28	8.6	41	62	64	48	55	90	23	350	17	14	69.3
Sulfate,total mg/l	35	43	35	38	48	32	28	26	63	108	102	89	81	101.9	26	430	29	51	101
Nitrate& NO2-N,total	<0.1	<0.1	<0.1	<0.1	0.18	0.14	0.2	<0.1	1.9	8.6	0.9	<0.1	0.11	0.16	<0.1	0.71	<0.1	<0.1	12
Ammonia Nitrogen, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.02	0.75	<0.1	<0.1	<0.1	<0.1	<0.1	0.12	<0.1	<0.1	0.13	<0 1	<0 1
**Unionized Ammonia, mg/l	0.006	0.012	0.004	0.002	0.002	0.001	0.006	0.022	0.001	0.001	0.001	0.003	0.002	0.002	0.001	0.037	0.004	0.005	0.001
Phenols,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5
Phosphorus,dis. mg/l	<0.01	0.03	0.09	0.02	0.05	0.07	0.04	0.21	1.1	2.4	0.86	0.04	0.05	0.21	0.15	1.7	0.09	0.05	4.8
Phosphorus,total mg/l	0.14	0.16	0.09	0.17	0.12	0.00	0.12	0.6	1.2	2.5	3.3	0.1	0.13	0.23	0.32	1.9	0.22	0.15	4.9
Cyanide,total mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BOD 5day mg/l	6	6	5	5	4	1	7	5	1	2	1	2	9	3	7	13	4	10	3
COD,total mg/l	26	42	24	27	24	10	39	21	23	21	26	16	16	25	46	46	25	49	28
Solids,tot.sus. mg/l	45	57	33	69	34	14	88	38	26	43	33	23	47	54	75	155	74	96	19
Solids,volatile mg/l	10	16	6	12	7	4	16	5	4	5	4	5	5	10	13	28	13	18	4
Kjeldahl-N,total mg/l	1.1	1.2	0.0	1.2	0.9	0.7	2.8	1.8	0.8	0.9	1.2	0.7	0.6	1.2	2.1	2.4	1.4	2.1	1.4
Oil,gravimetric mg/l	5	3	2	4	2	4	2	2	4	2	3	4	5	2	3	4	<1	1	2
Turbidity NTU	31	33	25	31	22	9.2	1.4	0.8	27	22	24	12	25	33	23	19	37	11	9.8
Arsenic,total ug/l	2	3	2	3	2	4	3	2	6	6	5	2	2	4	7	9	4	4	4
Mercury,total ug/l	<0.05	0.21	<0.05	<0.05	1.47	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.0	<0.05	<.05	<0.05	<0.05
Calcium,total mg/l	63	46	66	56	62	61	62	68	25	33	32	61	64	56	42	51	45	33	29
Calcium,dis. mg/l	62	46	65	54	62	60	61	69	24	32	31	62	61	56	41	51	45	31	29
Magnesium,total mg/l	24	19	27	21	26	25	27	25	10	14	14	28	28	27	23	24	21	24	14
Magnesium,dis. mg/l	23	19	27	20	26	25	27	26	10	13	13	29	28	27	23	23	21	22	14
Sodium,total mg/l	10	25	20	19	23	13	16	11	42	64	63	31	39	72	15	342	14	14	70
Sodium,dis. mg/l	17	26	20	19	23	13	16	12	42	63	62	33	39	72	15	343	14	13	70
Potassium,total mg/l	2.7	3.9	3.3	3.0	3.1	3.8	4.9	3.7	7.0	8.7	9.1	3.4	3.6	3.9	2.6	17	2.5	3.1	9.3
Potassium,dis. mg/l	2.5	3.7	3.1	2.6	3.0	3.7	4.6	3.7	6.8	8.5	8.9	3.5	3.5	3.8	2.4	17	2.3	2.8	9 4
Aluminum,total ug/l	921	882	689	1154	628	300	1444	411	896	842	781	453	569	1054	1080	1131	1519	1216	354
Aluminum,dis. ug/l	69	51	64	61	65	60	56	55	<50	<50	<50	<50	83	61	79	71	66	56	<50
Barium,total ug/l	156	120	167	165	162	156	216	171	56	55	52	149	134	169	196	112	157	146	38
Barium,dis ug/l	128	107	142	135	149	146	188	155	40	40	37	145	123	150	162	92	129	112	31
Boron,total ug/l	53	91	<50	66	73	<50	<50	<50	193	249	245	102	121	217	<50	1159 *	<50	51	244
Boron,dis. ug/l	51	91	<50	62	73	<50	51	<50	194	245	239	103	129	217	<50	1148	<50	51	247
Beryllium,total ug/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Beryllium,dis. ug/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium,total ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Cadmium,dis. ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Chromium,total ug/l	<5	<5	<5	<5	6	<5	<5	<5	<5	<5	<5	<5	<5	5	<5	<5	19	<5	<5
Chromium,dis. ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Copper,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	5	6	6	<5	<5	<5	<5	<5	6	<5	<5
Copper,dis. ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cobalt,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cobalt,dis. ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Iron,total ug/l	1464 *	1733	932	2467 *	1166 *	727	2120 *	2789 *	1374 *	1223 *	1117 *	638	1072 *	1527 *	1656 *	1244 *	2639 *	2448 *	622
Iron,dis. ug/lL	85	<50	<50	57	<50	<50	<50	69	<50	72	<50	<50	<50	<50	<50	<50	<50	151	<50
Lead,total ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Lead,dis. ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Manganese,total ug/l	707	867	857	1191 *	1348 *	1237 *	1637 *	3301 *	230	124	119	728	782	1036 *	813	257	791	1253 *	52
Manganese,dis. ug/l	325	482	579	949	1222	1169	1510	3132	160	83	79	624	671	972	320	158	672	801	31
Nickel,total ug/l	<5	5	<5	<5	<5	<5	<5	<5	6	8	7	<5	<5	6	<5	<5	59	<5	<5
Nickel,dis ug/l	<5	<5	9	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Silver,total ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<10
Silver,dis. ug/l	<3	<3	<5	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Strontium,total ug/l	192	158	196	174	209	195	194	239	75	101	99	218	227	226	137	672	139	143	95
Strontium,dis. ug/l	186	157	193	168	207	194	191	241	72	98	96	224	225	226	133	662	136	135	95
Vanadium,total ug/l	<5	7	<5	6	7	<5	<5	<5	12	12	10	5	<5	9	11	16	10	<5	<5
Vanadium,dis. ug/l	<5	<5	<5	<5	6	<5	<5	<5	0	8	7	<5	<5	5	10	13	6	<5	<5
Zinc,total ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Zinc,dis. ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
**Hardness. mg/l	256	192	276	224	261	254	265	274	106	140	135	269	274	251	199	225	200	179	132
Fecal coliform #/100ml	30	<200	<10	150	<200	30	60	370	<200	1000	200	480	160	<200	8200	6800	3100	10	3200
Fecal strep. #/100ml	20	<200	20	120	600	220	110	1600	1000	1600	800	280	260	1000	1800	4200	2400	740	8200

** Calculated value

* State General Use Water Quality Standard Violation

a: The allowable concentration varies in accordance with water temperature and ph values. In general, as both temperature and pH decrease, the allowable value of ammonia nitrogen increases.

Table 3. Water quality data from the LaMoine River Basin, Fall 1988.

STATION PARAMETER	DG-01	DG-02	OG-05	OG-06	OG-07	DG-08	OG-09	DGO-01	DGJ-02	OGJ-03	DGJ-04	DGL-02	DGL-03	DGL-04	OGL-05	DGLC-01	DGLO-01	DGIA-03	DGJA-01
**Water Quality Index Value	25.5	31.6	29.4	33 2	26.3	13	73.7	34.2	67.8	74.1	71.2	20.4	30.7	39.9	41.5	94.7	44		67.1
Temp. Air Deg.C	-	20	22	24	29	18	28	24	20	22	27	28.5	23	28	28	25	27	DRY	27
Temp. Water Deg.C	20.8	21.3	21.6	21.5	21.3	20.7	19.1	20.5	19.8	19.8	20.3	21.1	20.5	20	21	22	21.5	--	22.1
Field Dissolved Oxygen, mg/l	8.2	6.4	8.6	8.8	6.2	4.9 *	1.4 *	3.8 *	7.2	7.2	6.3	5.1	5.7	8.0	6.2	3.9 *	4.6 *	--	8.2
Field Conductivity, umhos/cm	575	617	557	602	606	526	420	516	710	689	688	680	675	1016	513	2600	455	--	666
Field pH, units	7.6	7	7.1	7.3	6.8	6.7	6.4 *	7.2	7.7	7.9	7.1	6.3 *	7.9	7.6	7.9	7.4	7.8	--	7.2
Alkalinity,total mg/l	240	204	244	215	251	253	154	256	83	54	50.9	212	186	225	206	146	167	--	49
Acidity,total	--	--	--	--	--	--	<0.1	--	--	--	--	<0.1	--	--	--	--	--	--	--
Fluoride,total mg/l	0.29	0.27	0.27	0.36	0.26	0.25	0.26	0.45	0.87	0.99	0.93	0.29	0.41	<0.1	0.34	1.68	0.24	--	0.98
Chloride,total mg/l	21	42	21	35	21.9	15	22	7.5	80	77	75	--	58	113	26	455	21	--	74
Sulfate,total mg/l	39	64	37	53	42	13	32	21	100	107	87.1	82	81	122	31	599	40	--	74
Nitrate& NO2-N,total	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	8.8	15	16	<0.1	<0.1	<0.1	0.19	0.99	<0.1	--	16
Ammonia Nitrogen, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.54	0.34	0.23	--	<0.1
**Unionized Ammonia, mg/l	0.002	0.000	0.001	0.001	0.000	0.000	0.000	0.001	0.002	0.003	0.000	0.000	0.003	0.002	0.019	0.004	0.007	--	0.001
Phenols,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	--	<5
Phosphorus,dis. mg/l	0.04	0.03	0.05	0.01	0.02	0.03	0.03	0.02	2.4	4.6	4.8	0.04	0.03	0.11	0.08	0.74	0.09	--	5.9
Phosphorus,total mg/l	0.12	0.17	0.11	0.17	0.14	0.09	0.116	0.16	2.6	4.6	5	0.12	0.14	0.28	0.23	0.81	0.19	--	6.1
Cyanide,total mg/l	<0.00	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	--	<0.005
BOD 5day mg/l	--	4	2	5	3	2	2	2	3	5	2	--	7	2	16	4	3	--	1
COD,total mg/l	21	22	19	24	27	18	26	24	25	25	24	20	20	34	52	33	25	--	22
Solids,tot.sus. mg/l	37	65	36	68	38	8	45	37	34	45	34	--	68	54	61	85	48	--	18
Solids,volatile mg/l	8	13	3	14	7	4	8	8	3	8	6	--	11	12	25	10	6	--	3
Kjeldahl-N,total mg/l	0.9	1.1	0.8	1.0	1.1	0.8	1.4	0.9	1.1	1.2	1.3	0.7	0.8	1.3	3.9	1.5	1.2	--	1.1
Oil,gravimetric mg/l	<1	3	3	6	3	2	10	--	6	8	3	4	13	5	4	4	4	--	7
Turbidity NTU	4.7	5.6	5.9	3.8	5.7	3.1	5	8	17	19	9.4	8.9	11	1	3.5	11	6.9	--	3.4
Arsenic,total ug/l	3	2	3	2	2	3	2	2	9	6	4	2	3	4	6	4	4	--	4
Mercury,total ug/l	<0.05	0.14	0.16	<0.05	<0.05	<0.05	0.1	<0.05	0.33	0.09	<0.05	<0.05	<0.05	<0.05	<0.0	0.2	0.1	--	<0.05
Calcium,total mg/l	70	61	69	62	73	63	45	61	34	31	30	75	68	59	49	68	48	--	29
Calcium,dis. mg/l	68	59	69	61	70	62	44	61	33	29	29	72	64	58	50	66	47	--	28
Magnesium,total mg/l	27	24	28	24	30	28	18	28	17	17	17	30	29	29	29	34	23	--	18
Magnesium,dis. mg/l	26	24	28	23	29	27	18	28	16	16	16	29	28	28	29	33	22	--	17
Sodium,total mg/l	23	40	19	36	22	16	20	13	89	83	79	34	43	120	20	443	21	--	76
Sodium,dis. mg/l	23	39	20	36	21	16	20	13	89	81	79	34	43	119	20	434	20	--	75
Potassium,total mg/l	3	4.2	2.6	4.0	3.5	4.1	6.1	4.2	11	12	12	3.4	4.2	6.3	5.9	21	3.9	--	11
Potassium,dis. mg/l	2.8	4	2.6	3.7	3.2	3.9	5.9	4.1	12	12	12	3.3	4.0	6.3	5.8	20	3.6	--	11
Aluminum,total ug/l	829	1250	977	1471	899	239	918	819	1168	1452	1448	428	904	1156	1699	1818	1654	--	583
Aluminum,dis. ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	--	<50
Barium,total ug/l	181	160	161	159	169	162	138	146	55	51	41	162	130	162	240	172	156	--	30
Barium,dis. ug/l	151	136	142	137	146	141	124	133	38	27	24	141	114	139	208	146	122	--	22
Boron,total ug/l	51	110	<50	100	<50	<50	55	<50	345	499	438	81	105	321	<50	1433 *	<50	--	279
Boron,dis. ug/l	51	115	<50	95	<50	<50	<50	<50	344	488	435	76	106	322	<50	1400	<50	--	272
Beryllium,total ug/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	<0.5
Beryllium,dis. ug/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	<0.5
Cadmium,total ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	--	<3
Cadmium,dis. ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	--	<3
Chromium,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	<5	--	7
Chromium,dis. ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	--	6
Copper,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	--	<5
Copper,dis. ug/l	<5	<5	<5	<5	<5	<5	<5	<5	21	<5	<5	<5	<5	<5	<5	<5	<5	--	<5
Cobalt,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	--	<5
Cobalt,dis. ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	--	<5
Iron,total ug/l	1648 *	2167 *	1568 *	2400 *	1583 *	1061 *	1337 *	1259 *	1603 *	2047 *	1818 *	926	1739 *	1671 *	2935 *	2059 *	2373 *	--	788
Iron,dis. ug/lL	<50	52	<50	<50	<50	<50	<50	<50	63	57	<50	54	<50	<50	105	<50	<50	--	<50
Lead,total ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<5	<5	<5	--	<50
Lead,dis. ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	--	<50
Manganese,total ug/l	1161 *	1347 *	668	1205 *	1101 *	823	910	794	117	109	87	1021 *	728	1040 *	1320 *	599	593	--	37
Manganese,dis. ug/l	831	1156	412	1052	926	598	781	640	60	62	55	805	489	931	1200	531	491	--	18
Nickel,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	<5	--	<5
Nickel,dis ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	--	<5
Silver,total ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	--	<3
Silver,dis. ug/l	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	--	<3
Strontium,total ug/l	187	179	188	173	220	190	141	206	141	140	136	207	213	215	149	986	139	--	129
Strontium,dis. ug/l	180	173	187	167	210	184	140	204	136	130	131	200	210	210	148	954	--	--	124
Vanadium,total ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	--	<5
Vanadium,dis. ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	--	<5
Zinc,total ug/l	<50	<50	<100	<50	<50	<50	<50	<50	<50	201	<50	<50	163	<50	<100	<50	<50	--	<50
Zinc,dis. ug/l	<50	<50	<50	<50	<50	<50	<50	<50	<100	294	<50	<50	<50	<50	<50	<50	<50	--	<50
**Hardness, mg/l	285	252	287	254	305	272	185	267	153	146	142	310	288	264	241	309	214	--	143
Fecal coliform #/100ml	85	60	45	200	20	--	100	140	540	2300	1000	100	100	20	3800	5600	3000	--	2000
Fecal strep. #/100ml	--	140	120	140	260	--	20	300	1600	800	1200	940	180	280	9300	3600	5900	--	3400

** Calculated value

* State General Use Water Quality Standard Violation

a: The allowable concentration varies in accordance with water temperature and ph values. In general, as both temperature and pH decrease, the allowable value of ammonia nitrogen increases.

TABLE 4. Water Quality Index category summary by component.

COMPONENT	DG-01	DG-02	DG-05	DG-06	DG-07	DG-08	DG-09	DGD-01	DGJ-02	DGJ-03	DGJ-04	DGL-02	DGL-03	DGL-04	DGL-05	DGLC-01	DGLD-01	DGIA-03	DGJA-01	MEAN
WQI	25.5	31.6	29.4	33.2	26.3	13	73.7	34.2	67.8	74.1	71.2	20.4	30.7	39.9	41.5	94.7	44	37	67.1	45.0
WATER TEMP	7.2	9.4	10.7	7.7	7.4	5.6	8.4	12.4	4.6	4.3	6.3	5.9	5.4	5.2	9.5	13.9	8.1	7.7	7.6	7.8
DISSOLVED OXYGEN	5.3	5.8	18.3	0	0	13.5	75.5	20	0	0	2.4	0	4.6	6.9	4.4	16	12.2	16.7	0	10.6
pH	1.1	5.4	3	3.1	4.3	6.3	14.5	2.4	1.8	2.5	5.5	13.5	2.9	2.1	4.4	2.4	2	2.5	4.6	4.4
TOTAL PHOSPHORUS	26.6	29.7	27.2	29	22.5	20.5	27.9	35	100	100	100	26.2	30.2	40.8	40.8	100	39.2	30	100	48.7
SUSPENDED SOLIDS	29.8	34.8	25.4	40.7	25.1	7	38.8	25	24.7	31.1	26.1	20.4	32.8	27.8	37.6	40.6	42.8	37.8	11.7	29.5
CONDUCTIVITY	15.7	15.8	15.7	15.7	16.6	14.8	14.2	14.7	18.2	18.2	18.5	17.7	17.7	22.4	13.6	39.6	12.9	14.4	18.5	17.6
METALS TOXICITY	10	10	10	10	23.5	10	10	10	11.5	10	15	10	10	10	10	10	10	10	10	11.1
AMMONIA TOXICITY	2.5	4.3	1.5	1	1.3	1.3	4.4	5.5	3.2	5.2	0	1.8	3.1	4.2	11.1	9.2	7.9	5.3	0.1	3.8

SEDIMENT CHEMISTRY

Introduction

(from Kelly and Hite, 1984)

Many toxic substances and contaminants of interest to persons concerned with pollution abatement sorb to particulates carried by water. Although heavy metals, nutrients, and oxygen demanding materials are naturally occurring sediment constituents, elevated levels can generally be attributed directly or indirectly to man. Pesticides, on the other hand, are not naturally occurring substances, and their detection in sediments attests directly to man's influence in the watershed.

Sediment analysis is particularly useful as a screening device to detect and identify contaminants periodically released from a point source discharge that are not readily detected by routine water quality sampling procedures. Sediment has additional advantages over other monitoring mediums because it is generally universally available in Illinois streams and may be collected when toxic contaminant levels have eliminated bioaccumulators such as fish. Collection and chemical analysis of stream sediments is thus a useful monitoring tool to document the extent of man's influence on the aquatic environment. It can be used to locate potentially harmful loadings, target areas where further monitoring is appropriate and identify areas where remedial actions are necessary.

Methods

Sediment can be defined as settleable material formerly carried in suspension which due to a drop in velocity has accumulated on the bottom (bed) of a river or stream. These sediments consist of a heterogeneous mixture of silt, clay, fine to coarse organic matter, and larger inorganic particles (e.g., sand and gravel). Because sediment deposition does not occur equally across the stream profile, field collectors typically search out areas of reduced flow (e.g., immediately downstream of sand and gravel bars, logs or other obstructions or areas of increased depth such as pools) where greater sediment deposition is likely to occur. Once deposits were found the upper layer of sediment was carefully removed using a sieve or long handled spoon and placed in a stainless steel pan. Sediment was taken from several deposits throughout the sampling reach and mixed before sieving.

All sampling equipment was constructed of stainless steel. Before each use, the equipment was washed in detergent and rinsed with deionized water and acetone. This was followed by a rinse with ambient water at the collection site to avoid contamination of the samples. All sediment samples on the LaMoine River Basin were collected by sieving through a 63-micron (U. S. Standard No. 230) stainless steel sieve. Sieving allows the collection of a known particle size (<63u) thus eliminating subjectivity of field personnel in finding "sediment" and decreasing variability between replicate samples thereby decreasing sampling error (Kelly and Hite, 1984).

Sieving was done in accordance with procedures outlined in the IEPA Field Methods Manual. Sieving resuspends the 63u sediment in ambient water and the coarse particles are discarded. The sieved sediment was placed in quart glass

jars and allowed to settle. The supernatant was decanted and the sediment placed in the appropriate containers for analysis: 8 oz. plastic for metals and 8 oz. glass for organics. The samples were frozen and delivered to the appropriate IEPA laboratory for analysis.

Results and Discussion

A total of nineteen sieved sediment samples were collected in the LaMoine River basin. Results were summarized in Tables 5 and 6. Samples were compared with the classification by Kelly and Hite for unsieved samples (Table 7). In addition, results were compared with sieved sediment data from ten additional Illinois river basins (Tables 8 and 9).

Chlordane

Total chlordane was classified as slightly elevated at DGJA-01 on Killjordan Creek (Table 7). Concentrations at the remaining stations were below detectable levels (5 ug/kg). As of 1988, chlordane was banned for use in the United States by the U.S. Environmental Protection Agency (personal communication).

Heptachlor Epoxide

Sediment heptachlor epoxide concentrations were below detectable levels (1 ug/kg) at all stations sampled.

DDT

Total DDT concentrations were below detectable levels (10 ug/kg) at all stations sampled.

Dieldrin

Dieldrin was detected at fourteen (73.7%) of the nineteen stations sampled. Concentrations ranged from 1 ug/kg at DGJ-02 on Troublesome Creek to 4.3 ug/kg on Drowning Fork (DGLC-01). The mean sediment concentration for the LaMoine basin was <2.2 ug/kg (Table 5). Dieldrin was the most frequently detected organochloride compound in Illinois stream sediments (Table 8). Aldrin/Dieldrin has been banned for use as an insecticide in the United States by the U.S. Environmental Protection Agency (Metcalf and Sanborn, 1975 as cited by Kelly and Hite, 1984).

Polychlorinated Biphenyls

Total PCBs were below detectable levels (10 ug/kg) at each station sampled.

Arsenic

Sediment arsenic concentrations ranged from highly elevated (19 mg/kg) at DG-08 on the upper LaMoine River to 2 mg/kg on Drowning Fork (DGLC-01). Excluding DG-08, all stations sampled were classified as non-elevated.

Cadmium

Sediment cadmium concentrations were classified as highly elevated at each station on the LaMoine River, Stations DGL-02 and 04 on the East Fork LaMoine,

DGD-01 on Missouri Creek, DGIA-03 on Grindstone Creek and DGJA-01 on Killjordan Creek. Concentrations were elevated at DGJ-03 and 04 on Troublesome Creek, at DGL-03 and 05 on the East Fork LaMoine, at DGLC-01 on Drowning Fork and at Station DGLD-01 on Farmers Fork. The remaining stations were classified as slight to non-elevated. Mean sediment cadmium concentrations ranged from 12 mg/kg in the DesPlaines to 0.5 mg/kg in the Mackinaw and Fox compared to 2.7 mg/kg in the LaMoine basin.

Chromium

Sediment chromium concentrations were classified as extremely elevated at DG1A-03 on Grindstone Creek. Concentrations at DG-08 on the LaMoine River, DGJA-01 on Killjordan Creek and DGJ-03 on Troublesome Creek had elevated classifications. The remaining stations were slightly to non-elevated. Mean sediment concentrations for chromium ranged from 13 mg/kg in the Fox basin to 62 mg/kg in the DesPlaines compared to 28.9 mg/kg in the LaMoine River basin (Table 9).

Copper

Sediment copper levels ranged from 130 mg/kg at DGIA-03 to 9.0 mg/kg at Stations DGJA-01 on Killjordan Creek and DG-07 on the LaMoine River. Levels were classified as highly elevated at DGIA-03 on Grindstone Creek. The remaining stations were classified as non-elevated. Mean sediment copper concentrations ranged from 11 mg/kg in the Elkhorn basin to 74 mg/kg in the DesPlaines compared to 17.1 mg/kg in the LaMoine basin (Table 9).

Iron

Sediment iron concentrations were classified as slightly elevated at DG-06, 08 and 09 on the mainstem LaMoine and DGIA-03 on Grindstone Creek. Concentrations were non-elevated at the remaining stations. Iron concentrations in the LaMoine basin ranged from 8500 on Killjordan Creek to 22,000 mg/kg at DG-08 on the LaMoine River. Mean sediment iron concentrations ranged from 15400 mg/kg in the Elkhorn basin to 79400 mg/kg in the Kishwaukee compared to 14657 mg/kg in the LaMoine basin (Table 9).

Lead

Sediment lead concentrations were classified as non-elevated at each station8in the LaMoine River basin. Mean concentrations ranged from 13 mg/kg in the Elkhorn basin to 134 mg/kg in the DesPlaines compared to 19.7 mg/kg in the LaMoine basin.

Manganese

In the LaMoine basin sediment manganese concentrations ranged from 270 mg/kg at DGJA-01 to 6100 mg/kg at DG-08 on the LaMoine River. Manganese concentrations were classified as extremely elevated at DG-08 in the LaMoine River, highly elevated at DGL-02 in the East Fork LaMoine and slightly elevated at DG1A-03 on Grindstone Creek. The remaining sixteen stations were classified as non-elevated. Basin wide mean concentrations ranged from 510 mg/kg in the DuPage to 980 mg/kg in the Mackinaw compared to 1142 mg/kg in the LaMoine (Table 9).

Mercury

Mercury values ranged from 0.01 to 0.03 mg/kg (Table 6). Concentrations at each of the nineteen stations were classified as non-elevated for mercury. Basin mean sediment concentrations ranged from 0.04 mg/kg in the Kyte to 0.7 mg/kg in the Vermilion compared to 0.019 mg/kg in the LaMoine basin (Table 9).

Zinc

Sediment zinc concentrations ranged from 5 to 60 mg/kg. Concentrations at all stations were classified as non-elevated. Mean sediment zinc concentrations ranged from 57 mg/kg in the Rock and Elkhorn basins to 323 mg/kg in the DesPlaines compared to 44.2 mg/kg in the LaMoine basin.

Volatile Solids, COD and Kjeldahl Nitrogen

Kelly and Hite (1984) found a high correlation between volatile solids, chemical oxygen demand (COD) and total Kjeldahl nitrogen (TKN). In the LaMoine basin, the highest levels of these constituents were found at DG-08 in the upper LaMoine River. The lowest levels of COD (14850 mg/kg) and total Kjeldahl nitrogen (664 mg/kg) were found near the mouth of the LaMoine River at DG-05. The lowest levels of % volatile solids were found at DGJA-01 on Killjordan Creek. Excluding DG-08 which was classified as slightly elevated for TKN and % volatile solids, all stations were classified as non-elevated for TKN, COD and percent volatile solids. Mean sediment COD and TKN levels in the LaMoine basin were lowest when compared to mean levels from ten Illinois river basins (Table 9). Mean percent volatile solids ranged from 4.2 mg/kg in the Elkhorn to 9.6 mg/kg in the DuPage compared to 4.6 mg/kg in the LaMoine basin (Table 9).

Phosphorus

Phosphorus concentrations ranged from 152 mg/kg at DGD-01 on Missouri Creek to 887 mg/kg at DGJ-04 on Troublesome Creek. Stations DCJ-04, DGL-04 and DG-08 were classified as slightly elevated with the remaining stations classified as non-elevated. Mean sediment concentrations ranged from 499 mg/kg in the Mackinaw basin to 1586 mg/kg in the DuPage compared to 466 mg/kg in the LaMoine basin (Table 9).

Summary

When compared to the classification in Kelly and Hite (1984) LaMoine River basin mean sediment concentrations were considered highly elevated for cadmium, elevated for chromium and non-elevated for percent volatile solids, COD, total Kjeldahl nitrogen, phosphorus, arsenic, copper, iron, lead, manganese, mercury and zinc. Mean chlordane, dieldrin, heptachlor epoxide, DDT and PCB concentrations were also classified as non-elevated.

When compared to sieved sediment data from ten Illinois river basins, the LaMoine had the highest mean manganese concentration and the lowest concentrations of COD, TKN, phosphorus, iron, mercury and zinc. However, only the DesPlaines had a higher mean cadmium level. Three basins had lower mean chromium, six basins had lower copper and three basins had lower mean lead concentrations.

Table 5. Summary of sediment organochlorine concentrations in the LaMoine River Basin, 1988.

All values are in ug/kg.

STATION	TOTAL PCB's	DIELDRIN	TOTAL DDT	TOTAL CHLORDANE	HEPTACHLOR EPOXIDE
DG-01	<10	<1	<10	<5	<1
DG-02	<10	<1	<10	<5	<1
DG-05	<10	<1	<10	<5	<1
DG-06	<10	1.5	<10	<5	<1
DG-07	<10	<1	<10	<5	<1
DG-08	<10	4.2	<10	<5	<1
DG-09	<10	3.3	<10	<5	<1
DGD-01	<10	1.3	<10	<5	<1
DGJ-02	<10	1	<10	<5	<1
DGJ-03	<10	2.2	<10	<5	<1
DGJ-04	<10	3	<10	<5	<1
DGL-02	<10	2.1	<10	<5	<1
DGL-03	<10	2.9	<10	<5	<1
DGL-04	<10	1.8	<10	<5	<1
DGL-05	<10	<1	<10	<5	<1
DGLC-01	<10	4.3	<10	<5	<1
DGLD-01	<10	2.7	<10	<5	<1
DGIA-03	<10	3.3	<10	<5	<1
DGJA-01	<10	3.3	<10	5.2	<1
DETECTION LIMIT ug/kg	10	1	10	5	1
%DETECTED	0	73.7	0	5.2	0
#SAMPLES	19	19	19	19	19
MIN	<10	<1	<10	<5	<1
MAX	<10	4.3	<10	5.2	<1
MEAN	<10	<2.2	<10	5.0	<1
SD	0	1.1	0	0	0

Table 6. Summary of sediment nutrients and metals concentrations in the LaMoine River Basin, 1988. All values are in mg/kg sediment dry weight.

STATION	%VOLATILE SOLIDS	COD	KJELDAHL NITROGEN	P	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Zn
DG-01	3.2	19150	713	399	3	4.3	21	10	16000	23	660	0.01	44
DG-02	4.3	23050	1020	444	5	4.6	17	10	16000	22	980	0.02	44
DG-05	3.2	14850	664	356	3	4.1	17	10	16000	20	760	0.02	41
DG-06	4.9	24000	1070	478	5	5	18	12	18000	22	800	0.02	53
DG-07	4.2	20700	917	480	4	3.3	16	9	14000	19	1100	0.02	5
DG-08	7.3	53550	2792	871	19	3.2	28	12	22000	22	6100	0.02	46
DG-09	5.7	35200	1520	551	4	4.8	19	12	19000	21	850	0.02	56
DGD-01	3.7	19500	858	152	4	2	17	11	15000	12	680	0.01	39
DGJ-02	3.7	24800	942	393	4	<1	18	10	11000	16	660	0.02	37
DGJ-03	3.9	27550	1034	468	4	1.3	23	10	12000	17	530	0.02	40
DGJ-04	4.3	31150	1169	887	4	1.4	20	12	12000	18	530	0.03	49
DGL-02	6.3	42250	1954	249	6	2.4	19	13	17000	22	3600	0.03	60
DGL-03	5.4	49050	2025	260	4	1.9	16	13	15000	26	810	0.02	60
DGL-04	5.3	34150	1170	881	3	3.6	17	10	15000	18	500	0.03	49
DGL-05	4.3	30000	1125	206	4	1	15	10	12000	14	640	0.01	36
DGLC-01	5.4	42500	1688	675	2	1	14	12	10000	20	390	0.02	51
DGLD-01	4.6	24050	1304	437	4	1.1	12	10	12000	15	450	0.01	36
DGIA-03	4.7	34150	1605	348	6	2.4	220	130	18000	26	1400	0.02	54
DGJA-01	3	25000	822	333	3	3	23	9	8500	22	270	0.02	40
# SAMPLES	19	19	19	19	19	19	19	19	19	19	19	19	19
MIN	3	14850	664	152	2	<1	12	9	8500	12	270	0.01	5
MAX	7.3	53550	2792	887	19	5	220	130	22000	26	6100	0.03	60
MEDIAN	4.3	27550	1125	437	4	2.4	18	10	15000	20	680	0.02	44
MEAN	4.6	30245	1284	467	4.8	2.7	28.9	17.1	14658	19.7	1143	0.019	44.2
SD	1.1	10278	522	215	3.5	1.4	45.2	26.6	3309	3.7	1359	0.006	11.9

Table 7. Classification of Illinois Stream Sediments (Kelly and Hite, 1984).

NUTRIENTS AND HEAVY METALS: Ranges of concentrations displayed and resultant groupings are based on one, two, four and eight standard deviations from background mean. Unless otherwise noted concentrations are in mg/kg sediment dry weight.

PARAMETER	NON-ELEVATED	SLIGHTLY ELEVATED	ELEVATED	HIGHLY ELEVATED	EXTREME
COD	90000	90000	132000	215000	380000
Total Kjeldahl Nitrogen	2300	2300	3200	5100	8800
Total Volatile Solids (%)	6.5	6.5	8.8	13	22
Total Phosphorus	800	800	1100	1700	3000
Arsenic	8.0	8.0	11	17	28
Chromium	16	16	23	38	60
Copper	38	38	60	100	200
Iron	18000	18000	23000	32000	50000
Lead	28	28	38	60	100
Manganese	1300	1300	1800	2800	5000
Mercury	0.07	0.07	0.10	0.17	0.30
Zinc	80	80	100	170	300
CADMIUM AND ORGANOCHLORINE COMPOUNDS: Ranges of concentrations and resultant groupings are based on 50, 65, 80 and 95 percent distributions for all samples. Cadmium concentrations are in mg/kg and organochlorine concentrations are in ug/kg sediment dry weight.					
Cadmium	0.5	0.5	1.0	2.0	20.0
Chlordane	5	5	6	10	40
Sum DDT	6.0	6.0	10	35	200
Dieldrin	3.5	3.5	6	10	25
Heptachlor Epoxide	1.0	1.0	1.5	3	9
PCBs	20	20	50	200	1500

Table 8. Summary of sieved (62u) sediment concentrations of organochlorine compounds in eleven Illinois river basins, 1982-88. Concentrations are in ug/kg dry weight.

Parameter (a) (Detection limit)		Des Plaines 1983/84	DuPage 1983	Elkhorn 1985	Fox 1982	Kishwaukee 1983	Kyte 1984	LaMoine 1988	Mackinaw 1987	Pecatonica 1984	Rock 1985	Vermilion 1986
Chlordane	No. of samples	38	21	5	23	25	6	19	22	23	14	20
(5ug/kg)	Percent detected	57.9	100	0	4.3	4.0	0	5.2	4.5	4.3	7.1	30
	Minimum	5.0	5.0	-	5.1	6.6	-	<5.0	<5.0	9.7	5.8	<5.0
	Maximum	100	50.0	-	5.1	6.6	-	5.2	5.0	9.7	5.8	16.0
	Mean	27	10.7	-	5.1	6.6	-	<5.0	<5.0	9.7	5.8	5.8
	Standard deviation	23	10.0	-	0	0	-	0	0	0	0	2.4
Total DDT	No. of samples	38	21	5	23	25	6	19	22	23	14	20
(10 ug/kg)	Percent detected	55.3	71.4	0	13.0	4.0	16.7	0	0	0	0	5
	Minimum	12	10	-	15	15.0	13	<10	-	-	-	<10
	Maximum	790	540	-	39	15.0	13	<10	-	-	-	12
	Mean	144	65.9	-	24.7	15.0	13	<10	-	-	-	10.1
	Standard deviation	201	134.6	-	12.7	0	0	0	-	-	-	0.4
Dieldrin	No. of samples	38	21	5	23	25	6	19	22	23	14	20
(1 ug/kg)	Percent detected	81.6	100	100	73.9	100	66.7	73.7	100	56.5	100	100
	Minimum	1.3	2.0	1.6	1.3	1.5	1.5	1	1.9	1.2	1.0	1.3
	Maximum	45	28.0	4.0	4.4	13.0	7.5	4.3	7.9	4.1	14.0	9.5
	Mean	8.6	7.1	2.5	2.5	4.9	3.5	2.2	5.4	2.1	3.8	3.6
	Standard deviation	10.6	5.7	0.9	0.8	3.0	2.7	1.1	1.5	1.1	3.6	1.7
Heptachlor	No. of samples	38	21	5	23	25	6	19	22	23	14	20
Epoxide	Percent detected	15.8	0	0	8.7	0	0	0	9.1	0	7.1	10
(1 ug/kg)	Minimum	1.4	-	-	1.0	-	-	<1	<1.0	-	1.4	<1.0
	Maximum	4.6	-	-	1.5	-	-	<1	1.4	-	1.4	2.6
	Mean	2.6	-	-	1.2	-	-	<1	1.0	-	1.4	1.1
	Standard deviation	1.4	-	-	0.4	-	-	0	0.1	-	0	0.4
PCBs	No. of samples	38	21	5	23	25	6	19	22	23	14	20
(10 ug/kg)	Percent detected	71.0	95.2	0	4.3	20.0	0	0	0	0	0	5
	Minimum	10	11	-	11	11	-	<10	-	-	-	<10
	Maximum	1200	430	-	11	600	-	<10	-	-	-	36
	Mean	259	56.1	-	11	136	-	<10	-	-	-	11.3
	Standard deviation	302	91.8	-	0	260	-	0	-	-	-	5.7

a)Aldrin, Endrin, Hexachlorobenzene, Hexachlorocyclohexane, Heptachlor, Lindane and Methoxychlor were not detected in any samples.

Table 9. Summary of sediment nutrients and metals concentrations in eleven Illinois river basins, 1982-88. All samples were sieved with a 62 u stainless steel sieve. Values are in mg/kg sediment dry weight.

Parameter		Des Plaines 1983/84	DuPage 1983	Elkhorn 1985	Fox 1982	LaMoine 1988	Mackinaw 1987	Kishwaukee 1983	Kyte 1984	Pecatonica 1984	Rock 1985	Vermillion 1986
Volatile Solids (%)	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	4.8	1.8	3.8	3.1	3	4.8	5.4	4.9	3.8	3.8	5.1
	Maximum	13.3	14.1	4.7	11.5	7.3	8.8	17.2	8	8.9	8.9	9
	Median	8.6	9.8	4.2	6.2	4.3	6.3	9.8	6.7	6.1	5.4	6.8
	Mean	8.7	9.6	4.2	6.7	4.6	6.6	9.5	6.6	6.2	5.6	6.9
	Standard deviation	2.1	2.8	0.4	2.2	1.1	1.2	3	1.1	1.8	1.4	1.1
COD	No. of samples	37	21	5	22	19	22	25	6	23	14	20
	Minimum	36000	48500	32900	32000	14850	28600	42300	39800	20400	33300	34300
	Maximum	224000	161000	41000	155000	53550	78300	202000	62100	79500	93600	84200
	Median	81000	90800	37200	65000	27550	44850	80900	50200	40700	43450	51750
	Mean	88000	93200	37200	73850	30244	46150	92100	50600	46000	49000	54830
	Standard deviation	38200	22300	3800	31000	10278	11017	41200	8300	16800	17500	13664
Kjeldahl Nitrogen	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	886	1840	1480	1050	664	1240	1620	1460	1000	1450	1190
	Maximum	4040	4790	2125	4560	2792	3060	6160	2350	2700	3620	4210
	Median	2635	3320	1610	2335	1125	2060	3320	2065	2020	1850	2115
	Mean	2582	3270	1740	2503	1283	2082	3380	1957	1790	2192	2208
	Standard deviation	835	682	285	953	522	469	1180	375	560	652	704
Phosphorus	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	342	700	481	407	152	348	359	338	327	403	395
	Maximum	4140	2160	649	1250	887	685	1520	753	853	943	1460
	Median	1100	1670	545	668	437	486	812	636	612	572	567
	Mean	1237	1586	561	704	466	499	782	597	613	606	651
	Standard deviation	844	430	74	188	214	81	257	152	149	126	251
Arsenic	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	0.1	4.2	3	3.8	2	4	2.3	2.7	0.1	3	4
	Maximum	21	9.4	4	20	19	9	8.8	6.4	4.6	6	9
	Median	7.4	5.9	3	5.7	4	5	4	3.8	2	4	5
	Mean	7.8	6.1	3	6.9	4.8	5.7	4.7	4.1	1.9	4	5.5
	Standard deviation	4.5	1.3	0	3.8	3.5	1.5	1.7	1.2	1.8	1	1.3
Cadmium	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	1	1	1	0.5	1	0.5	1	5	0.1	1	1
	Maximum	290	4	2	0.8	5	0.5	3	5	4.5	1	1
	Median	2	1	1	0.5	2.4	0.5	1	5	0.8	1	1
	Mean	12	1	1.2	0.5	2.7	0.5	1	5	0.9	1	1
	Standard deviation	47	0.9	0.4	0.1	1.4	0	1	0	0.9	0	0
Chromium	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	15	23	32	9	12	15	16	14	30.7	34	21
	Maximum	234	92	40	30	220	24	73	20	43.8	48	50
	Median	46	37	38	11	18	19	29	18	36.9	38	26
	Mean	62	38	37	13	28.9	19.4	32	18	37	38	30.6
	Standard deviation	54	14	3	5	45.2	2.4	14	2	3.7	4	9.1
Copper	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	17	23	9	10	9	13	12	9	6.2	9	15
	Maximum	220	130	13	35	130	19	140	15	25	20	43
	Median	46	58	9	14	10	15	20	13	14.9	13	22
	Mean	74	64	11	16	17.1	15	25	12	15.1	13	22.5
	Standard deviation	61	26	2	7	26.6	1.6	25	2	5	3	6.4
Iron	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	16800	10800	13000	5200	8500	18000	16000	17500	9639	12300	14000
	Maximum	42000	290000	18800	29000	22000	26000	400000	34000	24126	21800	26000
	Mc	30000	20600	15500	19000	15000	20000	22400	25600	15816	15850	21000
	Mean	29000	45200	15400	18400	14657	20590	79400	25600	15655	16400	20850
	Standard deviation	5852	76700	2400	4000	3308	2146	120800	5200	3488	2700	3395
Lead	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	14	25	10	10	12	10	11	30	5.3	5	11
	Maximum	480	270	17	93	26	33	76	31	70.5	19	97
	Median	95	59	14	16	20	14.5	18	30	13.8	16	22
	Mean	134	69	13	23	19.7	15	23	30	20.6	15	26
	Standard deviation	121	50	3	19	3.7	4.9	15	1	16.7	4	18
Manganese	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	380	250	450	460	270	250	110	460	291.1	480	510
	Maximum	2500	900	760	1700	6100	2700	1520	820	1260	920	1400
	Median	595	460	540	780	680	810	760	660	621.3	645	680
	Mean	690	510	580	810	1142	980	740	650	666.8	670	739
	Standard deviation	352	180	110	280	1358	547	360	160	250.2	119	211
Mercury	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	0.05	0.03	0.04	0.03	0.01	0.004	0.02	0.03	0.02	0.03	0.01
	Maximum	1.9	3.9	0.06	0.21	0.03	1.14	0.31	0.05	0.16	0.13	3.8
	Median	0.16	0.22	0.05	0.05	0.02	0.38	0.06	0.04	0.07	0.05	0.47
	Mean	0.44	0.45	0.05	0.06	0.019	0.4	0.07	0.04	0.07	0.06	0.7
	Standard deviation	0.52	0.81	0.01	0.04	0.006	0.2	0.07	0.01	0.03	0.03	0.88
Zinc	No. of samples	38	21	5	22	19	22	25	6	23	14	20
	Minimum	70	80	47	48	5	54	60	53	43.4	43	74
	Maximum	1400	500	62	180	60	83	310	65	297.1	78	170
	Median	175	190	61	66	44	65	90	70	75.8	54	105
	Mean	323	200	57	76	44.2	66	97	71	107.1	57	105
	Standard deviation	322	90	7	29	11.9	7.8	48	13	70.3	8	21

MACROINVERTEBRATES

Introduction

The use of macroinvertebrates to evaluate overall water quality is well established. Benthic communities are well suited for a bio-monitoring program in that they are relatively easy to sample and indicative of the quality of their environment. Each species is dependent on specific ranges of environmental conditions (i.e. water quality, habitat and flow) throughout its lifespan. The resulting community is an indication of these conditions over the weeks and months prior to collection. This makes the macroinvertebrate community especially useful under conditions of intermittent or mild organic enrichment when altered water quality is not readily detectable by conventional chemical surveys (Chutter, 1972). The underlying rational is that good water quality supports a diverse community containing pollution intolerant forms and that organic enrichment tends to restrict the number of species and simultaneously increase the density of pollution tolerant species (Keup et al. 1967).

Methods

Qualitive macroinvertebrate samples were collected at each station according to Agency guidelines (IEPA 1987). Macroinvertebrates were collected with a U.S. Standard No. 30 sieve or handpicked directly from rocks, logs and other debris. A uniform sampling effort was made at each station. All organisms were preserved in the field with 95% ethanol and returned to the laboratory for sorting and identification. Macroinvertebrates were identified to species level when possible and a Macroinvertebrate Biotic Index (MBI) was calculated for each site.

The MBI as used by IEPA is a modification of one developed by Hilsenhoff (1982). Each taxon has been assigned a pollution tolerance value from zero to eleven based on available literature and previous field experience. A value of zero is assigned to taxa known to occur in unaltered streams of high water quality. A value of eleven is assigned to taxa known to occur in severely polluted or disturbed streams. Intermediate values are assigned based on an organism's relative degree of tolerance or intolerance to pollution. The MBI is calculated from the formula:

$$MBI = \Sigma(m_i t_i)/N$$

Where m_i is the number of individuals in each taxon, t_i is the tolerance value assigned to that taxon and N is the total number of individuals in the sample. The MBI is an average of tolerance values weighted by abundance and is used as a measure of stream degradation.

Based on present assessment methods, MBI values reflect water quality as follows (IEPA, 1988):

< 5.0	Excellent
5.0 - 6.0	Very Good
6.1 - 7.5	Good/Fair
7.6 - 10.0	Poor
> 10.0	Very Poor

Results and Discussion

A total of 4725 aquatic macroinvertebrates were collected at seven stations on the LaMoine River and twelve stations on tributaries. The largest portion of the samples were aquatic insects, which contained 46 genera representing 29 families. The Diptera (flies, mosquitoes and midges) were the most common organisms, and comprised 18.4% of the total sample. These were followed by the Ephemeroptera (mayflys) 18.1%, Trichoptera (caddisflys) 16.2%, Coleoptera (aquatic beetles) 13.5%, Odonata (dragonflys and damselflys) 4.6% and Megaloptera (alderflies) 1.5%. The remainder of the sample was comprised of Turbellaria (flat worms) 8.9%, Mollusca (mussles and snails) 8.2%, Crustacea (crayfish, scuds, and sowbugs) 7.9%, Oligochaets (worms) 2.3%, and Hirudinea (leeches) 0.4%.

A total of 74 taxa were collected. The Odonata had the greatest diversity with 17 taxa, followed by Trichoptera 16, Ephemeroptera 14, Coleoptera 7 and Diptera 6 taxa. The remaining taxa included Mollusca 6, Crustacea 4 and Megaloptera, Turbellaria, Oligochaets and Hirudinea with 1 taxa each. *Stenacron interpunctatum* was the most widespread individual and was collected at 18 of the 19 stations. Results of individual stations are summarized in Table 10.

Macroinvertebrate Biotic Index (MBI) values on the LaMoine River ranged from 5.4 at DG-07 to 6.0 at DG-09. Total taxa collected ranged from 19 at DG-02 and 05 to 29 at DG-06 and DG-08. Variations in MBI values on the LaMoine River stations were probably due to variations in microhabitat (riffle-pool sequences versus pool only) rather than water quality. Substrate composition can influence the abundance and distribution of macroinvertebrates (Berkman, 1987). The mean MBI value for the LaMoine River was 5.6 with 24 taxa.

MBI values on the tributaries ranged from 4.9 at DGJ-02 on Troublesome Creek to 7.6 at DGIA-03 on Grindstone Creek. Troublesome Creek, just upstream from the confluence with the LaMoine River, was rated as having excellent water quality. Six tributaries (DGD-01, DGJ-04, DGL-03, DGL-04, DGLC-01 and DGLD-01) were rated as very good, four stations (DGJ-03, DGL-02, DGL-05 and DGJA-01) were rated as good with Station DGIA-03 rated as having poor water quality. The mean MBI for the twelve tributaries was 6.0 with 23 taxa.

Summary

Despite severe drought, which left many streams dry and a number little more than stagnant pools, viable macroinvertebrate communities were found at each station sampled. A total of 4725 macroinvertebrates were collected at seven stations on the LaMoine River and twelve stations on tributaries. By number, the Diptera were the most common organisms comprising 18.4% of the total sample. This is not totally unexpected as this order is among the largest aquatic insect groups. Ephemeroptera, Trichoptera and Coleoptera followed comprising 18.1, 16.2 and 13.5% of the total sample, respectively. *Stenacron interpunctatum* was the most widespread organism and was collected at eighteen of the nineteen stations sampled.

The tributaries had a lower mean MBI (6.0) when compared to the mainstem sites (5.6), however, both values represented very good water quality. Due to proximity, coal mining, agricultural and municipal wastewater treatment

facility influences would be greater in the tributaries. An estimated 85% of all stream miles consist of small first to third order streams (Leopold et al., 1964, as cited by Cummins, 1977 and IEPA 1980). In addition a large percentage (around 85%) of the wastewater treatment facilities discharge into small intermittent streams (IEPA, 1980).

The degree to which drought affected the macroinvertebrate communities is unknown. Certainly the potential exists, however, it is felt that at the stations sampled relatively healthy community were the norm and that major differences in community structures were due to microhabita variations.

Table 10. Macroinvertebrate Biotic Index indicator organisms collected in the LaMoine River.

TAXON	TOL RATING	DG-01	DG-02	DG-05	STATION DG-06	DG-07	DG-08	DG-0
TURBELLARIA	6	43	83	6	1	23	172	
OLIGOCHAETA	10	2	5		2	2	7	
HIRUDINEA	8							
Glossiphoniidae	8				1			
ISOPODA								
Caecidotea brevicauda	6	1					7	
C. intermedia	6							
AMPHIPODA	4							
Hyalella azteca	5	3	5	8	11			[illegible]
DECAPODA								
Cambaridae	5	1						
EPHEMEROPTERA								
Isonychia sp.	3	11			1			
Baetis sp.	4							
B. intercalaris	7	34			16	4		
B.pygmaeus	4							
Callibaetis sp.	4							
C. fluctuans	4				1	7	2	[illegible]
Heptagenia sp.	3	1						
H. diabasia	4							
Stenacron sp.	4							
S. interpunctatum	4	6	17	16		36	57	1[illegible]
Stenonema sp.	4				1			
S. ares	3	2						
S. exiguum	5				1	1		
S. femoratum (tripunctatum)	7							
S. pulchellum	3					1		
S. terminatum	4				1			
Tricorythodes sp.	5	6	9	8	5	1		
Caenis sp.	6		2					[illegible]
Hexagenia limbata	5					1	1	
ODONATA								
Dromogomphus sp.	4							
Gomphus sp.	7							
Progomphus sp.	5	1		2			1	
Boyeria sp.	3						3	
Macromia sp.	3						1	
Epitheca sp.	4							
Somatochlora sp.	1		4		2			[illegible]
Libellula sp.	8							
Hetaerina sp.	3							
Coenagrionidae	5.5							
Argia sp.	5							
A. apicalis	5			1				
A. moesta	5			1				
A. tibialis	5	5	17	2	1	11	7	[illegible]
A. translata	5	2						
Enallagma sp.	6			5		3		
E. civile	6			3				
E. divigans	6							
E. exsulans	6							
Nehalennia sp.	7						1	[illegible]
MEGALOPTERA								
Sialis sp.	4		1		1	5	5	5
TRICHOPTERA	3.5							
Hydropsychidae	5.5	12						
Cheumatopsyche sp.	6	19	8		19	54	8	
Hydropsyche sp.	5						6	
H. betteni	5							
H. bidens	5	84			1	22		
H. frisoni	5	11						
H. orris	4					2		
H. simulans	5				5	36		
Potamyia sp.	4	37						
Symphitopsyche sp.	4							
Chimarra sp.	3							
Cyrnellus sp.	5	6		5				
Hydroptilidae	2							
Hydroptila sp.	2					14		
Ochrotrichia sp.	4							
Orthotrichia sp.	1						1	
Ceraclea sp.	3		1					
Nectopsyche sp.	3		17	3	3	2	1	
Oecetis sp.	5		3	6	1	2	2	
COLEOPTERA								
Dineutus sp.(larvae)	4				6			[illegible]
Helichus lithophilus	4	5	23		11	1	1	[illegible]
Helodidae	7	2			1		3	[illegible]
Ancyronyx sp.	2			8			1	
A. variegatus	2							
Dubiraphia sp.	5	2			1	1		[illegible]
D. vittata	7		2	9			12	
Macronychus sp.	2							
M. glabratus	2			1	4		7	
Stenelmis sp.	7						3	
S. crenata	7	25	20	8	3	9		[illegible]
DIPTERA	10							
Tipulidae	4				1		1	
Chaoboridae	8					1		
Chaoborus sp.	8							
Palpomyia sp.	6							[illegible]
Simulium sp.	6							
Chironomidae	6	57	91	17	49	83	88	5[illegible]
Chironomus sp.	11						1	14
Tabanidae	7							
Tabanus sp.	7		1		1			
GASTROPODA								
Physa sp.	9	1	8	17	6	8	12	[illegible]
Lymnaea sp.	7							
Ferrissia sp.	7							
PELECYPODA								
Unionidae	1.5	2					6	
Sphaerium sp.	5	1		1	3	2	6	
Corbicula sp.	4							
TOTAL TAXA		27	19	19	29	26	29	21
TOTAL NUMBER ORGANISMS		382	317	127	160	332	423	147
MBI		5.5	5.6	5.7	5.6	5.4	5.7	6.[illegible]

Table 10. Macroinvertebrate Biotic Index indicator organisms collected in tributaries of the LaMoine River, 1980.

TAXON	DGA-01	DGJ-02	DGJ-03	DGJ-04	DGL-02	DGL-03	DGL-04	DGL-05	DGLC-01	DGLD-01	DGTA-03	DGJA-01
						STATION						
TURBELLARIA	16		27	18	14	7		3		5		
OLIGOCHAETA		1	9		61	1	8	10		1		
HIRUDINEA												
Glossiphoniidae								13	1	2		
ISOPODA												
Caecidotea brevicauda												
C. intermedia	7		17	10						[illegible]		
AMPHIPODA												
Hyalella azteca	14	40	77	99	13	9	18	7		12		
DECAPODA												
Cambaridae	1			1	1	1	1			1	1	
EPHEMEROPTERA												
Isonychia sp.		5	3		2	2				1		
Baetis sp.		10		1		2						
B. intercalaris		34	93	19	3	6				1		33
B. pygmaeus				4								
Callibaetis sp.			2			1						
C. fluctuans	5											
Heptagenia sp.												
H. diabasia			2									
Stenacron sp.					5							
S. interpunctatum	5	38	11	17	8	8	16	12	5	22	1	8
Stenonema sp.		4				7			1			
S. ares												
S. exiguum					6	2						
S. femoratum		2										1
S. pulchellum					15							
S. terminatum					6							
Tricorythodes sp.		6			5	20		2				
Caenis sp.	6	11	2	6		1	2		10		5	9
Hexagenia limbata	1	1	3	3		1	2		1	1	1	
ODONATA												
Dromogomphus sp.	1											
Gomphus sp.		1			3							
Progomphus sp.		3			2	1						
Boyeria sp.												
Macromia sp.					1							
Epitheca sp.												
Somatochlora sp.									8			1
Libellula sp.										5	2	
Hetaerina sp.			1	1								2
Coenagrionidae			3									
Argia sp.			3									
A. apicalis												
A. moesta												
A. tibialis		8			4	2	1	2	6	1		
A. translata												
Enallagma sp.	7		1	1			1		1			
E. civile				4				1	11	4		
E. divagans								4				
E. exsulans					1	3						
Nehalennia sp.			24	5		1				2		3
MEGALOPTERA												
Sialis sp.	9	3	11	5	7	3	8		1	7		
TRICHOPTERA												
Hydropsychidae						26						
Cheumatopsyche sp	3	49	16	29	48	33		6	12	10		44
Hydropsyche sp.				3								
H. betteni			7	3					2	4		4
H. bidens												
H. frisoni			5		4					11		
H. orris						2		1				
H. simulans		16				3		6				
Potamyia sp.												
Symphitopsyche sp.						1						
Chimarra sp.						3						
Cyrnellus sp.												
Hydroptilidae	1											
Hydroptila sp.												
Ochrotrichia sp.				4		2						
Orthotrichia sp.												
Ceraclea sp.					1	3		1				
Nectopsyche sp.	2	6			2							
Oecetis sp.	1											
COLEOPTERA												
Dineutus sp.Claro	1											
Helichus lithophi	2		2		6	1	1	11		4	2	
Helmidae	4	1	11	2	1	1	2	4		[illegible]		1
Ancyronyx sp.												
A. variegatus												
Dubiraphia sp.	10	79					18	9	2		1	
D. vittata			64	32	8	19				1		1
Macronychus sp.												
M. glabratus		26	3	3	8	7	3	6	1	10		
Stenelmis sp.												
S. crenata		9	3	1	11	6	1	17	2	10		
DIPTERA												
Tipulidae												
Chaoboridae											1	
Chaoborus sp.												
Palpomyia sp.					4		3	3		1		
Simulium sp.			1									
Chironomidae	45	11	55	14	138	13	50	20	10	21	5	8
Chironomus sp.					6		4					
Tabanidae							3					
Tabanus sp.									1			
GASTROPODA												
Physa sp.	12	5	41		5	4	3	43	19	23	26	13
Lymnaea sp.								7				
Ferrissia sp.									4		2	
PELECYPODA												
Unionidae					11	10	1					
Sphaerium sp.	8	27		2	6	5	1	10	3	14		
Corbicula sp.											1	
TOTAL TAXA	22	25	27	22	32	33	21	23	19	27	12	15
TOTAL NUMBER ORGANISM	159	454	499	290	416	217	127	138	101	200	48	128
MBI	5.7	4.9	6.4	5.6	6.2	5.3	5.7	6.6	5.9	5.9	7.6	6.4

HABITAT

Introduction

Stream habitat consists of two major components: chemical and physical. Both suitable water quality and desirable physical habitat (i.e., flow, current velocity, bottom substrate composition, cover, etc.) must exist to meet specific individual species requirements. To determine the degree of use supported by a given stream segment, it is necessary to determine its existing biotic condition (IBI) and evaluate it in light of its potential. Potential from the IEPAs perspective is that which would occur without water quality limitations. It should be possible to determine stream potential from an assessment of existing physical habitat.

Methods

A method modified from Gorman and Karr (1978) was used to assess physical habitat. Instream physical habitat data were collected at six equally spaced transects along a 100 yard stream segment. Measurements of depth, water velocity and substrate composition were recorded at equal increments across the transect based on mean stream width:

Mean Stream Width		Increment Spacing (feet)
	10	1
10	30	2
30	60	3
60	100	5
100		10

Observation of pool/riffle development, instream cover, shading, riparian vegetation and adjacent land use practices were also recorded. Stream hydrology and morphology as well as substrate values were calculated from the field data and used to assess the biotic potential of the study area. The biotic potential is calculated by the following formula: Predicted IBI= 40.1 - (0.126 X silt/mud) - (0.123 X claypan) + (0.0424 X pool) + (0.0916 X width). Silt/mud, claypan, and pool are all expressed as percentages and mean width is measured in feet. Measurements were taken with a USGS wading rod and Swoffer instruments digital velocity meter.

Comparisons of PIBI values should only be made between streams of the same stream order.

Results and Discussion

Physical habitat was to be evaluated at fourty-four locations in the LaMoine River basin. However, a majority of the lower order tributaries were completely dry due to a severe drought, which left the area 10.58 inches below normal precipitation for April through September. A total of nineteen stations had the minimum of 100 yards continuous pool required to assess physical habitat according to IEPA methodology. Of the nineteen stations, DG-01, 05 and 09 on the LaMoine River and DGL-04 on the East Fork LaMoine were too deep to assess. Results are summarized in Table 11.

Predicted IBI values for the LaMoine River stations ranged from 40.5 at DG-07 to 45.2 at DG-02 with a mean of 43.0 (Table 11). This indicated that the LaMoine River had the biotic potential of a highly valued aquatic resource. Generally discharge and water width increased at downstream stations, however, depths fluctuated with pool-riffle sequences. LaMoine River discharge ranged from 0.2 cfs at DG-08 to 7.3 cfs at DG-06, with a mean value of 3.5 cubic feet per second. Stream width ranged from 30 feet at DG-08 to 54 feet at DG-02. The LaMoine River had a mean width of 44.5 feet. To facilitate physical habitat data collection, wadable pool/riffle sequences were selected as sampling sites wherever possible. Stream depths reflected site selection and ranged from 0.73 at DG-06 to 1.37 feet at DG-07. Approximately seventy-five percent of the substrate in the LaMoine River was comprised of silt-mud (37.7) or sand (34.3).

Predicted IBI values for the twelve tributaries ranged from 31.9 DGLC-01 on Drowning Fork to 43.2 at DGL-03 on the East Fork LaMoine River. The mean PIBI value for the tributaries was 38.9. Missouri Creek at DGD-01, Troublesome Creek at DGJ-04, Killjordan Creek at DGJA-01 and the East Fork LaMoine River at DGL-03 had PIBI values indicative of highly valued aquatic resources. The remaining reaches were classified as moderate aquatic resources. The tributaries varied greatly in width and discharge. Width ranged from 7 feet at DGL-05 to 28 feet at DGL-03. Average stream width for the tributaries was 17.6 feet. Discharge ranged from 0 cubic feet per second (cfs) at DGD-01, DGIA-03 and DGL-05 to 2.2 cfs at DGJ-04. Tributary substrate was composed primarily of silt-mud (38.3%) and sand (25.6%) (Table 11).

Mean PIBI values were reduced in the LaMoine (40.0) when compared to the Mackinaw (43.6) and Vermilion (44.6) basins. Mean stream width was also reduced in the LaMoine basin (24.8 feet) when compared to mean values for the Vermilion (57.6) and Mackinaw (36.7) basins. Percent silt mud in the LaMoine was increased (38.1) compared to the Vermilion (4.8) and Mackinaw (7.2) basins (Day, 1987, Short 1988). Comparisons between physical habitat parameters and predicted IBI showed significant spearman rank correlations at the 95% level for fine gravel (r_S=0.58), water width (r_S=0.77) and silt-mud (r_S=-0.72). Percent silt-mud and water width are both used when calculating the predicted IBI. Effects of drought (i.e. reduced stream width as well as elevated silt-mud percentages) had great influence on habitat (PIBI) in the LaMoine River basin.

Summary

The severity of the drought was realized by comparing published U.S. Geological Survey Water Data (Report 16-87-2) taken from the LaMoine River at Ripley (DG-01). Average discharge at Ripley was 825 cfs compared to 7.45 cfs recorded at DG-01 in July 1988. The period of record was 66 years. The mean PIBI value for the LaMoine Basin was 40.0 which indicated that the LaMoine River had the biotic potential of a moderate aquatic resource. Three of the four mainstem stations as well as four of the eleven tributary reaches were characterized as highly valued aquatic resources. LaMoine predicted IBI values were depressed when compared to those for the Mackinaw and Vermilion basins. Potentially, the effects of drought (i.e. reduced stream width as well as elevated silt-mud percentages) on PIBI values are great as both parameters are used when calculating the index. Silt-mud was greatly increased and stream width reduced in the LaMoine basin when compared to other central Illinois basins.

Table 11. Summary of habitat data collected in the LaMoine River basin, 1988.

TION CODE	DG-02	DG-06	DG-07	DG-08	DGD-01	DGIA-03	DGJ-02	DGJ-03	DGJ-04	DGJA-01	DGL-02	DGL-03	DGL-05	DGLC-01	DGLD-01
ICTED INDEX OF BIOTIC POTENTIAL	45.2	44.7	40.5	41.6	41.9	40.4	39.4	35.4	43.1	41.3	38.6	43.2	36.2	31.9	37.2
PLING REACH															
tion Length - Fish (ft.)	1320		2000		305							420	547		100
al Transect Reach - Habitat (ft.)	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Habitat Transects	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
nsect Interval (ft.)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
rement Width (ft.)	3	5	3	2	2	2	1	2	3	2	2	2	1	1	1
al No. Habitat Sample Points	189	109	143	153	126	128	113	85	81	56	118	141	63	102	123
al No. Velocity Measurements	189	109	143	153	126	128	113	85	81	56	118	141	63	102	123
Channel Width Measurements	11	11	11	11	11	10	11	11	8	11	11	11	11	11	11
Stream Segments	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
STRATE															
t-Mud (<0.062mm)	32.3	17.4	58.0	43.1	34.9	49.2	21.2	58.8	9.9	0.0	34.7	14.2	50.8	86.3	61.0
nd (0.062-2mm)	42.9	59.6	8.4	26.1	15.1	13.3	52.2	23.5	14.8	60.7	42.4	27.0	23.8	3.9	4.9
ne Gravel (0.08-0.3 mm)	7.4	9.2	2.8	0.7	21.4	4.7	10.6	0.0	3.7	23.2	3.4	5.7	3.2	1.0	1.6
dium Gravel (0.3-0.6 inches)	1.1	1.8	1.4	0.0	6.3	5.5	6.2	2.4	8.6	12.5	3.4	5.7	1.6	0.0	1.6
rse Gravel (0.6-2.5 inches)	1.1	0.0	2.1	3.9	0.8	11.7	0.0	2.4	32.1	0.0	0.0	18.4	0.0	0.0	0.0
all Cobble (2.5-5.0 inches)	4.8	0.0	6.3	7.8	0.0	6.3	0.0	4.7	18.5	0.0	0.0	27.0	0.0	0.0	0.0
rge Cobble (5.0-10.0 inches)	6.9	0.0	7.7	7.2	1.6	3.1	0.0	0.0	4.9	0.0	0.0	0.7	0.0	0.0	0.0
ulder (>10 inches)	0.0	0.0	2.8	3.3	0.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
drock	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
aypan - Compacted Soil	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	1.2	0.0	0.0	0.0	7.9	0.0	0.8
ant Detritus	1.6	5.5	7.0	3.3	9.5	2.3	5.3	3.5	2.5	3.6	10.2	0.0	7.9	7.8	22.8
getation	0.5	0.0	0.0	0.0	2.4	0.0	0.0	3.5	0.0	0.0	0.0	0.0	1.6	1.0	0.0
merged Logs	0.5	6.4	3.5	4.6	6.3	0.0	4.4	1.2	3.7	0.0	5.9	1.4	1.6	0.0	7.3
her	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAULIC FEATURES															
scharge (cfs)	4.8	7.3	1.6	0.2	.0	0.0	0.5	2.0	2.2	1.4	0.7	0.5	.0	0.4	0.2
an Channel Width (ft)	96	131	81	63	58	41	78	35	41	33	65	76	33	31	35
an Width of Water (ft)	54	53	41	30	24	25	11	17	24	12	24	28	7	10	12
an Velocity (ft/sec)	1.04	0.95	0.18	0.38	1.00	0.00	0.57	0.73	0.93	0.43	0.49	0.44	0.20	0.29	0.45
an Velocity - Sampling Reach	0.00	0.15	0.01	.00	0.00	0.00	0.19	0.22	0.27	0.52	0.02	0.07	0.04	0.09	0.02
an Depth (ft)	1.13	0.73	1.37	1.26	1.00	0.48	0.55	0.99	0.94	0.18	0.29	0.35	0.23	0.26	0.70
ol	100.0	46.0	93.0	99.0	97.5	100.0	22.0	27.0	50.5	1.0	15.5	54.0	66.5	41.0	88.0
ffle	0.0	0.5	2.5	0.0	2.5	0.0	5.5	6.5	35.5	18.5	7.0	12.5	7.5	0.0	11.0
ER															
stream Cover	2.4	10.3	3.3	10.7	9.4	6.3	27.8	13.5	8.6	8.3	4.7	5.0	13.1	11.5	11.0
ading	23.5	21.0	37.0	72.0	52.0	23.0	72.5	17.5	95.5	65.2	54.5	88.0	64.5	6.0	65.0
stream Cover (ft 2)	380	1645	407	960	693	475	957	700	621	308	277	420	265	362	403

FISH

Introduction

In order to classify streams, the Illinois Department of Conservation (IDOC) and IEPA formed the Biological Stream Characterization (BSC) work group in 1983. The BSC developed a five tier classification based largely on the attributes of lotic fish communities. Interest in fish was increased due to development of Karr's Index of Biotic Integrity or IBI (Karr, 1986) and the desire to produce a method of classifying streams biologically that could be used by both IDOC and IEPA. In the absence of adequate fishery data, macroinvertebrate or physical habitat descriptors (in that order) may be used to develop provisional stream classifications.

Methods

Fish were collected through a cooperative effort by IDOC and IEPA staff. Depending on stream conditions, samples were collected with a boat-mounted electroshocker or electric minnow seine. Collections were sorted into size groups, weighed, counted and identified in the field. Fish not readily identifiable in the field were preserved in formalin for later identification.

For this study, fish were converted to IBI values. The IBI assesses the quality of the stream based on twelve metrics:

1. Total number of fish species
2. Number of darter species
3. Number of sunfish species
4. Number of sucker species
5. Number of intolerant species
6. Proportion of green sunfish
7. Proportion of omnivores
8. Proportion of insectivorous cyprinids
9. Proportion of top carnivores
10. Number of individuals
11. Proportion of hybrids
12. Proportion of diseased individuals

The index assigns values from 1 to 5 for each metric resulting in a maximum IBI of 60. Streams were then classified.

IBI RANGE	CLASS
60-51	A stream; unique aquatic resource
50-41	B stream; highly valued aquatic resource
40-31	C stream; moderate aquatic resource
30-21	D stream; limited aquatic resource
20	E stream; restricted aquatic resource

Results and Discussion

A total of 15184 fish were collected from nineteen stations in the LaMoine River basin. Excluding hybrid blue/green sunfish, a total of fourty-nine species were collected. Within family groupings, most of the species collected were minnows, and carps with fourteen. These were followed by suckers with eleven species; darters or perch, sunfish and catfish with six each; and gars with two. The collection also included white bass, black-stripe minnows, gizzard shad and freshwater drum (Table 12).

The most widespread species were the red shiner and green sunfish, which were collected at each of the nineteen stations. These were followed by bluntnose minnows at eighteen (95%), johnny darters at sixteen (84%); quillback at fourteen (74%); creek chubs and shorthead redhorse at thirteen (68%); suckermouth minnows, sand shiners and redfin shiners at twelve (63%); central stonerollers at eleven (58%) and carp and yellow bullhead collected at ten (53%) stations (Table 12). The remaining taxa were collected from less than one-half of the stations sampled.

Stream reaches were evaluated using comparisons between the index of biotic integrity (IBI), which is a measure to the existing biotic condition as defined by fish community structure, and the predicted index of biotic integrity (PIBI) which evaluates potential using select physical habitat parameters. Spearman rank correlation (r_s) was used to evaluate relationships between IBI and predicted IBI (PIBI). The predicted IBI showed a significant correlation with the IBI (r_s=0.53 at the 95% level). A significant positive correlation (r_s=0.74) for IBI and stream width and a significant negative correlation (r_s=0.76) for percent instream cover and IBI was also found (Cochran and Snedcore 1980).

IBI values in the LaMoine River basin ranged from 32 at DGJ-04 on Troublesome Creek to 52 at DGL-03 on the East Fork LaMoine River and DG-02 on the LaMoine River. The basin had a mean IBI of 41.7. According to the IBI, stations DG-02, DG-07 and DGL-03 were classified as unique aquatic resources, seven stations were classified as highly valued and nine had moderate classifications (Table 12).

The seven mainstem LaMoine stations had IBI values ranging from 36 at DG-09 to 52 at DG-02. The mean IBI for the LaMoine River was 44.0. Stations DG-02 and DG-07 were classified as unique aquatic resources, whereas DG-01, 06 and 08 were classified as highly valued. Stations DG-05 and 09 were classified as moderate resources. Corresponding habitat data (PIBI) were collected at DG-02, 06, 07 and 08. Excluding DG-06 the IBI exceeded the predicted (PIBI) at each station. The depressed IBI value at DG-06 may have been habitat/sampling gear related as percent instream cover was increased (10.3%) when compared to DG-02 (2.4%) and DG-07 (3.3%). A similar percentage was found at DG-08. Rank correlation indicated that decreased cover tended to increase IBI values. Intuatively, increased instream cover could reduce

sample gear efficiencies (catchability) ultimately depressing IBI values. MBI and WQI values indicated that water quality at DG-06 was similar when compared to other LaMoine River stations.

Tributary IBI values ranged from 32 at DGJ-04 to 52 at DGL-03. The tributaries had a mean IBI of 40.4. One station, DGL-03 on the East Fork LaMoine River, was classified as an unique aquatic resource. Four stations, DGL-02 and 04 on the East Fork LaMoine, DG1A-03 on Grindstone Creek and DGJA-01 on Killjordan Creek, were classified as highly valued aquatic resources. The remaining seven stations were classified as moderate aquatic resources. IBI values for DGD-01 on Missouri Creek, DGJ-02 and 04 on Troublesome Creek and DGL-05 on the East Fork LaMoine River were lower than corresponding predicted values (PIBI). Although, the aformentioned IBIs were lower than corresponding PIBIs, existing conditions approximated predicted (95%) at DGD-01, and DGL-05 and will be considered equal. The IBI at DGJ-04 was the lowest value in the LaMoine River basin and may have been due in part to sampling efficiency. IDOC field notes indicated that the electrofishing equipment did not appear to be immobilizing the fish properly. The cause of the low IBI value at DGJ-02 in unknown. Elevated total phosphorus was the only apparent water quality related problem at either DGJ-02 or 04. Stations on Troublesome Creek, Drowning Fork and the East Fork LaMoine River were located downstream from either the Macomb or Bushnell municipal wastewater treatment facilities. In each instance, stations located immediately downstream from these facilities had IBI values which exceeded corresponding PIBIs.

Summary

The mean IBI value for the LaMoine River basin was 41.7 which classified the basin as a highly valued aquatic resource. Basinwide, three stations were classified as unique aquatic resources, seven were classified as highly valued and nine were classified as moderate aquatic resources. Compared to the mainstem, the tributaries had depressed classifications, however, these may be habitat or drought, related as IBI values approximated or exceeded predicted IBI at nine of the twelve tributary stations. Based on IBI/PIBI values no evidence of impairment due to municipal wastewater treatment facilities was found, as each station located immediately downstream from a facility had an IBI which exceeded the corresponding PIBI. Lastly, a significant positive correlation was found for stream width and IBI suggesting that to a degree the larger the stream the higher the IBI. If this were indeed true, a drought severe enough to drastically alter flow characteristics of a stream (decreased stream width and increased pool) could alter IBI values dramatically, especially in the smaller headwater streams where pools constitute the only refuge for the resident fish population of entire reaches.

Table 12. Fish data from the LaMoine River basin. 1988.

	DG-01	DG-02	DG-05	DG-06	DG-07	DG-08	DG-09	DGD-01	DGJ-02	DGJ-03	DGJ-04	DGL-02	DGL-03	DGL-04	DGL-05	DGLC-01	DGLD-01	DGIA-03	DGJA-01
Index Of Biotic Integrity (IBI)	45	53	40	42	51.3	42.5	36	40	36	36	32	50	52	44	36	36	38.2	42	42
bigmouth buffalo	1		2		2														
bigmouth shiner		7		99								10			2	2	1	28	318
black crappie			1		1														
black bullhead								1											
black buffalo	1	3	1	2	1		2												
blackside darter		1			1			3				2						24	
blackstripe topminnow	1														95	418	4	11	
bluegill	1	2	19	2			2												
bluntnose minnow	26	58		3	9	41	1	24	8	29	3	162	137	5	1	14	3	1177	29
carp	22	64	8	28	20		21	3						6	8		6		
central stoneroller				1	1			7	7	10	25	30	87			5		618	10
channel catfish		6	1	2	6	9	2		2			3			1				
common stoneroller																			
creek chub		3		1				16	80	27	48	12	24		4	5	19	125	390
emerald shiner	17	174	11	192	2														
fantail darter																		17	
flathead catfish	2	1	1			1								2					
fathead minnow										1					1	4	5		
freckled madtom	1				1							1							
freshwater drum	17	3	13	2	2														
gizzard shad	61	4	280	2	19		183	1											
golden redhorse	1	2			3	10		1		2			8					14	
golden shiner																		1	
green sunfish	13	6	1	6	21	17	30	48	48	68	17	11	8	62	57	1	33	326	1
highfin carpsucker	1	1			3		17							2					
hornyhead chub												14	27		3	7	3	25	
hybrid blue/green					1									5					
johnny darter		1		2	1	1	1	1	13	6	4	240	73	23	2	8		445	35
largemouth bass	1		2			2	1							1				2	
longnose gar		1	1																
northern hogsucker						2						27	36	1					
orangethroat darter		4									29		4					66	
quillback	2	10	2	12	5	7	9	7				10	8	3	11			42	1
rainbow darter													1						
red shiner	92	620	10	377	142	90	6	162	239	152	39	1465	143	94	366	347	73	362	17
redfin shiner		4			2	2		22	5	11	9		2	75	4		2	646	
river carpsucker	4	11	2	6	6	2	6					2							
sand shiner		8		24					86	46	11	198	41		14	38	2	131	162
shorthead redhorse	5	7	2	3	20	21	3	11	4			59	26	5				2	
shortnose gar			1		1														
silver redhorse		1			1	1							8						
slenderhead darter	16	13			12							27	14	1					
smallmouth bass					22	12						32	36					14	
smallmouth buffalo	1	3	7																
stonecat												4	7						
suckermouth minnow	1			1				4	22	7	36	154	140		8	2		31	5
white bass			9																
white crappie		1			1		4							1	2				
white sucker				1				14	27	43	6		1				16	42	25
yellow bullhead								1	9	4	1		4		13	17	7	50	6
Total Number Individuals	287	1019	374	766	306	218	288	326	550	406	228	2463	835	286	592	868	174	4199	999
Total Taxa	22	28	20	20	27	15	15	17	13	13	12	20	22	15	17	13	13	23	12

AQUATIC LIFE USE SUPPORT

Introduction

A primary mission of the IEPA Division of Water Pollution Control is to protect and enhance the waters of the State. The Illinois General Use Standards are considered synonymous with the fishable/swimmable goal of the Clean Water Act. Aquatic life use is generally the most sensitive instream use in terms of water quality requirements. Water quality suitable for protection of aquatic life therefore should assure other beneficial uses. The Agency's use assessment methodology focuses on aquatic life uses and is consistent with USEPA guidance on use attainability.

Methods

The degree to which Illinois streams supported designated uses was determined using a combination of biotic and abiotic data, intensive survey field observations and professional judgement. Biotic data consisted of fishery and macroinvertebrate data. These data were evaluated using the index of biotic integrity (IBI) and the IEPA macroinvertebrate biotic index (MBI) respectively.

Abiotic data included water and sediment chemistry and physical habitat data. Stream habitat data were used to assess biotic potential through a PIBI value predicted from multiple regression analysis. It includes such metrics as depth, velocity, substrate and instream cover. Water chemistry data were evaluated through a STORET-generated water quality index (WQI) and a review of constituents influencing WQI values. Sediment chemistry was occasionally factored into the use support assessment.

Field observations and professional judgement were selectively factored into use attainability assessments. Field forms were reviewed for comments and observations which provided insight into pollution sources or other causes of use impairment. Professional judgement and knowledge of the study areas proved particularly useful where index values appeared to be based on unrepresentative samples and/or conflicting data.

Four levels of aquatic life use support assigned to Illinois stream reaches include Full, Partial/Minor, Partial/Moderate and Nonsupport.

Full Use Support - All streams which were rated as "A" streams on the basis of IBI values greater than 51 were considered attaining full use support. Those streams characterized as "B" streams (IBI values 41-50) were considered to be in full use support if the actual IBI value equaled or exceeded the PIBI value (based on habitat), and water quality did not appear limiting. Sites determined as attaining full use support may, however, exhibit some minor problems, but not of a magnitude to impact aquatic life use or to be considered minor impairment.

Partial Support/Minor Impairment - In general, use impairment determinations were made by reviewing differences between the biotic potential (PIBI) and IBI value. A site or stream reach was considered to be partially supporting aquatic life uses with minor impairment if the biotic potential was 4 units higher than the IBI and the WQI was less than 70. If the actual IBI value equalled or exceeded the biotic potential and water quality appeared to be limited (WQI greater than 60) the stream reach was also considered to exhibit partial support/minor impairment.

Partial Support/Moderate Impairment - Those stream sites where biotic potential exceeded actual IBI values by a substantial margin, and/or where WQI values exceeded 70, were considered to have partial support/moderate impairment.

Nonsupport - Stream reaches considered in nonsupport of aquatic life use included areas where IBI values were equal to or less than 23.

RESULTS AND DISCUSSION

Assessments of the degree to which LaMoine River streams supported designated uses were either monitored, based on biotic and abiotic data and professional judgement; or evaluated based on observations, professional judgement and knowledge of the study area. The monitored designation included reaches that lacked data, but were considered representative (i.e. located immediately upstream) of assessed reaches with current data. Thirty-four USEPA reach segments were monitored and nine were evaluated (Table 13). Three monitored stations, DGJA-01 on Troublesome Creek, DGZN-01 on Prairie Creek and DGN-01 on Cedar Creek were located on tributaries to reach segments.

Of the 359.7 stream miles monitored, 249 were rated as attaining full use support. This encompassed the lower 62.3 miles of the LaMoine River and 186.7 miles on thirteen tributaries (Table 13). Tributaries which were designated full use support included Town Branch (DGA-01), West Creek (DGB-01), Missouri Creek (DGD-01 and 02), Little Missouri Creek (DGDA-01), Williams Creek (DGHA-01), Farmers Fork (DGLD-01), the East Fork LaMoine River (DGL-02, 03, and 04), portions of Cedar Creek (DGG-02 and 03) and the South Branch LaMoine River. Although some of these stations may have had water quality and/or habitat limitations, they were not of a magnitude to the considered minor use impairment.

An additional 91.1 stream miles were evaluated. This included the headwaters of the LaMoine River, Grove Creek (GDQ-01), Long Creek (DGZO-01), Cedar Creek (DGN-01), LaHarpe Creek (DGP-01), Rock Creek (DGPB-01), Baptist Creek (DGPC-01) and Spring Creek. Each of these reaches were rated as attaining full use support.

Of the 359.7 stream miles monitored, 110.75 were rated as partially supporting designated aquatic life uses with minor impairments. This included 20.8 miles of the Upper LaMoine River (DG-09 and 10) and portions of Troublesome Creek (DGJ-03, 04 and 05), Cedar Creek (DGG-01) and LaHarpe Creek. Drowning Fork (DGLC-01), the headwaters of the East Fork LaMoine River (DGL-05), Prairie Creek (DGZN-01), Killjordan Creek (DGJA-01) and Grindstone Creek (DG1A-03 and 04) were also rated partial/minor.

The partial/minor classification is based largely on actual instream conditions (IBI) which fail to meet predicted (PIBI). IBI values exceeded the PIBI at DGJ-03 on Troublesome Creek, DGLC-01 on Drowning Fork and DGJA-01 on Killjordan Creek, however, elevated WQI values, due mainly to high phosphorus concentrations, limited the rating to partial/minor. Generally, reaches with the partial minor ratings were located downstream from municipal wastewater

treatment facilities. Stream use by livestock compounded the problems on Killjordan and Grindstone Creeks. Organic enrichment from feed lots was responsible for the partial/minor rating at DGG-01 on Cedar Creek.

No individual stations were rated as partial/moderate or nonsupport.

Summary

A total of 450.8 stream miles (USEPA stream reach lengths) were assessed in the LaMoine River basin. Of these, 340.75 miles were rated as attaining full use support. This included the lower three-fourths of the LaMoine River as well as reaches on nineteen tributaries. Portions of the upper fourth of the LaMoine River, the South Branch LaMoine, Troublesome Creek, and the East Fork LaMoine River as well as Grindstone, Killjordan and Prairie Creeks and Drowning Fork were designated partially supporting aquatic life uses with minor impairments. Generally, reaches with partial/minor ratings were located downstream of municipal sewage treatment facilities. No reaches were rated partial/moderate or nonsupport.

Table 13. Assessment of degree of use support for the LaMoine River basin, 1988.

WATER BODY IDENTIFIER	STATION CODE	REACH INDEX	WATER BODY NAME	T	SIZE	DATE	ASS LEV	USE USE	DEGREE OF USE SUPPORT	W.Q. LIM.	CAUSES	SOURCES	WQI VALUE	MBI VALUE	IBI VALUE	PIBI VALUE
ILDG01	DG-05	07130010-001/on	La Moine R.	R	8.5	1988	M	01	FULL	N			29.4	5.7	40	--
ILDGA01	DGA-01	07130010-002/on	Town Cr.	R	7.2	1988	M	01	FULL	N			--	--	--	--
	DGB-01	07130010-003/off	West Cr.		7.5	1988	M		FULL	N			--	-	--	--
	DG-01	07130010-003/on	La Moine R.	R	9.5	1988	M	01	FULL	N			25 5	5.5	45	--
		07130010-004/on	La Moine R.	R	0.5	1988	M	01	FULL	N			--	--	--	--
	DGZO-01	07130010-005/on	Horney Branch	R	7.6	1988	M	01	FULL	N			--	--	--	--
ILDG02	DG-06	07130010-006/on	La Moine R.	R	9.5	1988	M	01	FULL	N			33.2	5.6	42	44.7
	DG-02	07130010-007/on	La Moine R.	R	11.9	1988	M	01	FULL	N			31 6	5.6	53	45 2
ILDG03		07130010-008/on	La Moine R.	R	0.5	1988	M	01	FULL	N			--	--	--	-
ILDGI01		07130010-009/on	Camp Cr.	R	2.6	1988	M	01	FULL	N			--	--	--	--
ILDGIA01	DGIA-03	07130010-010/on	Grindstone Cr.	R	14.7	1988	M	01	PARTIAL/MINOR	T	9(S),11(M),12(S)	2(S),14(S)	37	7.6	42	40.4
	DGI-01	07130010-011/on	Camp Cr.	R	23.1	1988	M	01	FULL	N			--	--	--	--
		07130010-012/on	La Moine R.	R	6.8	1988	M	01	FULL	N			--	--	--	--
	DGJA-01	07130010-013/off	Killjordan Cr.	R	6.6	1988	M	01	PARTIAL/MINOR	T	9(H),11(S)	02(H),10(S)	67.1	6.4	42	41.3
ILDGJ01	DGJ-02	07130010-013/on	Troublesome Cr.	R	4.9	1988	M	01	FULL	N			67.8	4.9	36	39.4
	DGJ-03	07130010-013/on	Troublesome Cr.	R	3.8	1988	M	01	PARTIAL/MINOR	T	9(H),11(M)	02(H),10(S),71(S)	74.1	6.4	36	35.4
	DGJ-04	07130010-013/on	Troublesome Cr.	R	11.4	1988	M	01	PARTIAL/MINOR	T	9(H),11(S)	02(H),10(S)	71.2	5.6	32	43.1
ILDG04	DG-04	07130010-014/on	La Moine R.	R	1.9	1988	M	01	FULL	N			43.5	--	--	--
	DG-07	07130010-015/on	La Moine R.	R	6.1	1988	M	01	FULL	N			26.3	5.4	51.3	40.5
ILDGL01	DGL-02	07130010-016/on	E. Fk. La Moine R.	R	6.4	1988	M	01	FULL	N			20.4	6.2	50	38.6
	DGL-03	07130010-016/on	E. Fk. La Moine R.	R	6.5	1988	M	01	FULL	N			30.7	5.3	52	43.2
	DGL-04	07130010-017/on	E. Fk. La Moine R.	R	10.35	1988	M	01	FULL	N			39.9	5.7	44	--
		07130010-017/on	E. Fk. La Moine R.	R	3.05	1988	M	01	PARTIAL/MINOR	T	9(S),11(H)	2(S),10(M)	--	--	--	--
ILDGLC01	DGLC-01	07130010-018/on	Drowning Fork	R	17.8	1988	M	01	PARTIAL/MINOR	T	09(S),11(M),12(S)	02(H),11(M),14(H)	94.7	5.9	36	31.9
		07130010-019/on	E. Fk. La Moine R.	R	0.9	1988	M	01	PARTIAL/MINOR	T	09(S),11(M),12(S)	11(S),14(H)	--	--	--	--
ILDGL02	DGL-05	07130010-020/on	E. Fk. La Moine R.	R	16.4	1988	M	01	PARTIAL/MINOR	T	9(S),11(M),12(S)	11(S),14(H)	41.5	6.6	36	36.2
ILDGLD01	DGLD-01	07130010-021/on	Farmer Cr.	R	13.0	1988	M	01	FULL	N			44	5.9	38.2	37.2
		07130010-022/on	Spring Cr.	R	2.1	1988	E	01	Full	N			--	--	--	--
	DGZM-01	07130010-023/off	Prairie Cr.		7.6	1988	M		PARTIAL/MINOR	T	6(S),9(M),12(S)	2(H),10(S)	--	--	--	--
		07130010-023/off	Cedar Cr.	R	18.1	1988	M		FULL	N			--	--	--	--
	DG-08	07130010-023/on	La Moine R.	R	7.1	1988	M	01	FULL	N			13	5.7	42.5	41.6
	DG-09	07130010-023/on	La Moine R.	R	7.1	1988	M	01	PARTIAL/MINOR	T	9(S),11(M),12(H)	2(S),10(S)	73.7	6	36	--
		07130010-023/on	La Moine R.	R	7.1	1988	M	01	FULL	N			--	--	--	--
ILDG05		07130010-024/on	La Moine R.	R	1.8	1988	M	01	PARTIAL/MINOR	T	9(S),11(M)	10(S)	--	--	--	--
ILDGP01	DGP-01	07130010-025/on	La Harpe R.	R	5.5	1988	E	01	FULL	N			--	--	--	--
ILDGPB01	DGPB-01	07130010-026/on	Rock Cr.	R	9.7	1988	E	01	FULL	N			--	--	--	--
		07130010-027/on	La Harpe R.	R	1.0	1988	E	01	FULL	N			--	--	--	--
ILDGPC01	DGPC-01	07130010-028/on	Baptist Cr.	R	12.3	1988	E	01	FULL	N			--	--	--	--
		07130010-029/on	La Harpe R.	R	14.0	1988	E	01	FULL	N			--	--	--	--
		07130010-030/on	La Moine R.	R	5.2	1988	M	01	PARTIAL/MINOR	T	9(S),11(M)	10(S)	--	--	--	--
	DG-10	07130010-031/on	La Moine R.	R	6.7	1988	M	01	PARTIAL/MINOR	T	9(S),11(M)	10(S)	--	--	--	--
ILDGR01		07130010-032/on	S. Br. La Moine R.	R	6	1988	E	01	PARTIAL/MINOR	T	6(H),9(H),12(S)	2(H)	--	--	--	--
		07130010-032/on	S. Br. La Moine R.	R	5.9	1988	E	01	FULL	N			--	--	--	--
		07130010 033/on	La Moine R.	R	12.8	1988	E	01	FULL	N			--	--	--	--
ILDGQ01	DGQ-01	07130010-034/on	Grove Cr.	R	8.3	1988	E	01	FULL	N			--	--	--	--
	DGZO-01	07130010-035/on	Long Cr.	R	7.3	1988	M	01	FULL	N			--	--	--	--
	DGE-01	07130010-036/on	Bronson Cr.	R	12.9	1988	M	01	FULL	N			--	--	--	--
ILDGH01		07130010-037/on	Flour Cr.	R	1.9	1988	E	01	FULL	N			--	--	--	--
	DGH-01	07130010-038/on	Flour Cr.	R	15.0	1988	E	01	FULL	N			--	--	--	--
ILDGHA01	DGHA-01	07130010-039/on	Williams Cr.	R	12.4	1988	E	01	FULL	N			--	--	--	--
ILDGG01	DGG-01	07130010-040/on	Cedar Cr.	R	16	1988	E	01	FULL	N			--	--	--	--
ILDGG01	DGG-01	07130010-040/on	Cedar Cr.	R	1.7	1988	E	01	PARTIAL/MINOR	T	9(H),12(H)	16(H)	--	--	--	--
ILDGO01	DGO-01	07130010-041/on	Missouri Cr.	R	4.8	1988	M	01	FULL	N			34.2	5.7	40	41.9
	DGO-02	07130010-042/on	Missouri Cr.	R	16.5	1988	M	01	FULL	N			--	--	--	--
ILDGOA01	DGOA-01	07130010-043/on	Little Missouri Cr.	R	12.1	1988	M	01	FULL	N			--	--	--	--

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Appendix A. LaMoine River Intensive basin sampling station location descriptions.

STATION CODE	STREAM NAME	COUNTY	1/4 SEC.	TWP.	RANGE	Station Location
DG-01	Lamoine R.	Brown/Schuyler	NE33	1N	2W	Old U.S. 24 Br. at Ripley
DG-02	Lamoine R.	Schuyler	SE20	3N	3W	IL. Rt. 101 Br. at Brooklyn
DG-05	Lamoine R.	Brown/Schuyler	NW13	1S	2W	Twp. Rd. Br., 2.0 mi. NE of Cooperstown
DG-06	Lamoine R.	Schuyler	SE23	2N	3W	Dirt road, 0.5 mi. NE of Erwin, no br.
DG-07	Lamoine R.	Hancock	SE12	4N	5W	Co. Rd. #6, 1.25 mi. W. of Colmar
DG-08	Lamoine R.	Hancock	SE22	5N	5W	Twp. Rd. Br. 6.0 mi. W. of Tennessee
DG-09	Lamoine R.	Hancock	NE13	5N	6W	Co. Rd. #17 Br., 5.0 mi. ENE of Carthage
DG-10	Lamoine R.	Hancock	NW12	6N	6W	Twp. Rd. br. 1.0 mi. W of LaCrosse
DGA-01	Town Br.	Schuyler	SW26	1N	2W	Il. Rt. 103 br. 2.0 mi.ENE of Ripley
DGB-01	West Cr.	Brown	SW31	1N	2W	Twp. rd. br. 2.0 mi. WSW of Ripley
DGDA-01	Little Missouri Cr.	Schuyler	SW32	2N	3W	Il. RT. 99 br. 3.0 S of Camden
DGD-01	Missouri Cr.	Schuyler	SE34	2N	3W	Twp. Rd. Br. 1.5 mi. SW of Erwin
DGD-02	Missouri Cr.	Schuyler	SE26	2N	4W	Dirt rd. 3.0 mi. SW of Camden
DGG-01	Cedar Cr.	Schuyler	NW17	2N	3W	Il. Rt. 99 br. N of Camden
DGG-02	Cedar Cr.	Schuyler	NE9	2N	4W	Twp. Rd. br. 1.25 mi. S of Huntsville
DGHA-01	Williams Cr.	Schuyler	NW21	3N	4W	Dirt rd. ford 5.5 mi. E of Augusta
DGH-01	Flour Cr.	Schuyler	SW9	3N	4W	Twp. rd. ford 2.5 mi. SW of Birmingham
DGIA-03	Grindstone Cr.	McDonough	SW28	4N	3W	Co. Rd. #8, 4.5 mi. S. of Fandon
DGIA-04	Grindstone Cr.	McDonough	SW20	4N	2W	Twp. rd. br. 3.0 mi. SW of Industry
DGI-01	Camp Cr.	McDonough	SE19	4N	3W	Twp. rd. br. 4.0 mi. S of Fandon
DGJA-01	Killjordan Cr.	McDonough	SW22	5N	3W	Co. Rd. #18 Br., 4.0 mi. SW of Macomb
DGJ-02	Troublesome Cr.	McDonough	SE9	4N	4W	Co. Rd. #24, 2.0 mi. E. of Colmar
DGJ-03	Troublesome Cr.	McDonough	SW31	5N	3W	Twp. Rd. Br., 1.6 mi. WNW of Fandon
DGJ-04	Troublesome Cr.	McDonough	SW28	5N	3W	Twp. Rd. ford, 5.5 mi. SW of Macomb
DGK-01	Bronson Cr.	Hancock	NW24	4N	5W	Twp. rd. br. 2.0 mi. N of Plymouth
DGLC-01	Drowning Fork	McDonough	NW8	6N	1W	Twp. Rd. Br., 2.0 mi. SW of Bushnell
DGLD-01	Farmer Fork	McDonough	NE12	6N	2W	Twp. Rd. Br., 2.0 mi. N. of Bardolph
DGL-02	E. Fork Lamoine R.	Hancock	SW24	5N	5W	Twp. Rd. Br., 4.5 mi. W. of Tennessee
DGL-03	E. Fork Lamoine R.	McDonough	SW11	5N	4W	Twp. Rd. Br., 1.5 mi. NW of Colchester
DGL-04	E. Fork Lamoine R.	McDonough	NE20	6N	2W	Twp. Rd. Br., 2.0 mi. NW of Macomb
DGL-05	E. Fork Lamoine R.	McDonough	NW7	6N	1W	Twp. Rd. Br., 3.0 mi. SW of Bushnell
DGN-01	Cedar Cr.	Hancock	SE8	5N	5W	Twp. rd. br. 4.0 mi. SSE of Webster
DGPB-01	Rock Cr.	Hancock	NW21	6N	5W	Twp. rd. br. 2.0 mi. NNW of Fountain Green
DGPC-01	Baptist Cr.	Hancock	SW10	6N	5W	Twp. rd. br. 3.2 mi. N of Fountain Green
DGP-01	LaHarpe R.	Hancock	NW30	6N	5W	Twp. rd. br. 1.5 mi NW of Webster
DGQ-01	Grove Cr.	Hancock	SW11	6N	6W	Twp. rd. br. 2.4 mi. NE of Burnside
DGZD-01	Horney Br.	Schuyler	NE6	1N	2W	Twp. rd. br. 6.0 mi. WSW of Rushville
DGZN-01	Prairie Cr.	Hancock	NW11	5N	5W	Twp. rd. br. 4.0 mi. NE of Carthage
DGZO-01	Long Cr.	Hancock	NW3	5N	6W	Twp. rd. br. 3.5 mi NE of Carthage

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5. Supplementary Notes

5. Abstract (Limit: 200 words)

In July, 1988, the Illinois Environmental Protection Agency (IEPA) and the Illinois Department of Conservation (IDOC) participated in a cooperative survey of the LaMoine River, a sixth order tributary to the Illinois River, to evaluate the aquatic resources of the basin. Water and sediment chemistry, macroinvertebrates, fish and/or instream habitat data were sampled at nineteen stations to assess biotic potential and assign use support ratings. Site selection included one station which was part of the IEPA stream monitoring network (AWQMN). One of the driest years in history was 1988 and resulted in a 13.19 inch departure from the basins 37.6 inch average yearly precipitation. USGS records indicated that the 66 year average discharge for the LaMoine River at Ripley(DG-01) was 825 cubic feet per second compared to 7.5 cubic feet per second, measured at DG-01 in August 1988. The drought dessicated a majority of the lower order tributaries and generally reduced the mainstem LaMoine to a series of pools. Any conclusions based on these data should take into account the conditions under which the data were collected.

7. Document Analysis a. Descriptors

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